Universidad Autónoma de Madrid

Facultad de Medicina

Departamento de Medicina Preventiva, Salud Pública y Microbiología

CONDUCTAS ALIMENTARIAS ASOCIADAS AL EXCESO DE PESO, Y ACUERDO CON LAS PRINCIPALES RECOMENDACIONES NUTRICIONALES EN POBLACIÓN ESPAÑOLA DE ALTO RIESGO CARDIOVASCULAR

Tesis doctoral

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D. Fernando Rodríguez Artalejo, Catedrático del Departamento de Medicina Preventiva, Salud Pública y Microbiología de la Facultad de Medicina de la Universidad Autónoma de Madrid, y Dña. Mª Pilar Guallar Castillón, Profesora Titular del mismo Departamento,

INFORMAN:

Que Dña. Maritza Muñoz Pareja ha realizado bajo su dirección el trabajo titulado "Conductas alimentarias asociadas al exceso de peso, y acuerdo con las principales recomendaciones nutricionales en población española de alto riesgo cardiovascular". Es un trabajo original, rigurosamente realizado, y es apto para ser defendido públicamente con el fin de obtener el grado de doctor.

Para que así conste y surta los efectos oportunos, se firma este documento en Madrid, a 6 de septiembre de 2013.

Fdo. Dr. Fernando Rodríguez Artalejo

Fdo. Dra. Mª Pilar Guallar Castillón

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Maritza Muñoz Pareja ha recibido una beca del Gobierno de Chile para estudios de Doctorado – Becas Chile

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ÍNDICE GENERAL

ALCANCE DE LA TESIS

Esta tesis se presenta como un compendio de los cuatro artículos siguientes:

- Artículo 1:

  Mesas AE, Muñoz-Pareja M, López-García E, Rodríguez-Artalejo F. *Selected eating behaviours and excess body weight: a systematic review*. Obesity Reviews 2012, 13(2):106-135. (JCR Impact Factor 2011: 7.038)

- Artículo 2:

  Muñoz-Pareja M, León-Muñoz LM, Guallar-Castillón P, Graciani A, López-García E, Banegas JR, Rodríguez-Artalejo F. *The Diet of Diabetic Patients in Spain in 2008–2010: Accordance with the Main Dietary Recommendations—A Cross-Sectional Study*. PLoS ONE 2012, 7(6): e39454. doi:10.1371/journal.pone.0039454. (JCR Impact Factor 2011: 4.092)

- Artículo 3:

  Guallar-Castillón P, Muñoz-Pareja M, Aguilera MT, León-Muñoz LM, Rodríguez-Artalejo F. *Food sources of sodium, saturated fat and added sugar in the Spanish hypertensive and diabetic population*. Atherosclerosis 2013, http://dx.doi.org/10.1016/j.atherosclerosis.2013.04.001. (JCR Impact Factor 2011: 3.794)

- Artículo 4:

  Muñoz-Pareja M, Guallar-Castillón P, Mesas AE, López-García E, Rodríguez-Artalejo F. *Obesity-related eating behaviors are associated with higher food energy density and higher consumption of sugary and alcoholic beverages: A Cross-Sectional Study*. PLoS ONE 2013 (In press). (JCR Impact Factor 2011: 4.092)

RESUMEN

Las enfermedades cardiovasculares (ECV) son una importante causa de carga de enfermedad en España y en otros países desarrollados, incluyendo Europa y Estados Unidos de América, siendo la principal causa de muerte en nuestro país. La urbanización, industrialización y globalización que acompañan la transición económica traen consigo cambios en los modos de vida que propician las ECV. Surgiendo factores de riesgo como la dieta inadecuada, el consumo de tabaco, y la inactividad física.

Para controlar las ECV se necesitan estrategias poblacionales e intervenciones clínicas, que prioricen a aquellos pacientes de alto riesgo. Para implantar de forma racional y evaluar ambos tipos de intervenciones se necesita disponer de información sobre la historia natural de la ECV en la población. El Estudio de Nutrición y Riesgo Cardiovascular (ENRICA) es un estudio nacional con entrevista y examen (National Health Interview and Examination Surveys - NHIES) realizado en una muestra representativa de la población española, cuyos objetivos fueron determinar la frecuencia y la distribución de los principales componentes de la historia natural de la ECV en España, incluidos la dieta y otros factores de riesgo conductuales, los factores de riesgo biológicos, la lesión temprana de órganos diana y la morbilidad diagnosticada.

Esta tesis se realiza en el marco del estudio ENRICA, siendo las hipótesis propuestas que algunas conductas alimentarias, tales como saltarse alguna comida, comer rápido, hasta saciarse, fuera de casa, entre horas o de forma irregular, consumir comida rápida, y comprar comida para llevar, se asocian con el exceso de peso. Y que conductas alimentarias relacionadas con la obesidad, entre ellas comprar snacks en máquinas expendedoras, comer alimentos precocinados, en restaurantes de comida rápida o mirando la TV, no planear cuanto comer antes de sentarse a la mesa, no elegir alimentos bajos en grasa y no quitar la grasa de la carne ni la piel del pollo antes de comerlos, se asocian al consumo de raciones de mayor tamaño y de alimentos con elevada densidad energética, a un mayor número de ocasiones de ingesta, y una mayor ingesta de bebidas azucaradas y alcohólicas. Otras hipótesis fueron que la dieta de los pacientes diabéticos españoles tiene un bajo acuerdo con las principales recomendaciones nutricionales. Y que en la población de diabéticos e hipertensos adultos españoles las principales fuentes alimentarias de sodio son el pan, los

embutidos y las sopas, de grasas saturadas son el queso curado, la bollería, la carne roja, los embutidos y la leche entera, y de azúcares añadidos, son el azúcar añadido directamente al café u otras bebidas, la bollería, los refrescos azucarados y el yogurt entero. Para responder a estos supuestos se definieron los siguientes objetivos: examinar la asociación entre las conductas alimentarias y el exceso de peso. Así como también, su asociación con el tamaño de la ración consumida, la densidad energética de los alimentos consumidos, el número ocasiones de ingesta diarias, y el consumo de bebidas azucaradas y alcohólicas. Valorar el grado de acuerdo de los pacientes diabéticos con las principales recomendaciones nutricionales, e identificar las principales fuentes alimentarias de sodio, grasas saturas y azúcares añadidos de individuos hipertensos y diabéticos españoles.

Para ello se tomaron datos del estudio ENRICA, un estudio transversal realizado de junio de 2008 a octubre de 2010 en 12.948 individuos representativos de la población española no institucionalizada de 18 y más años. La información se recogió en tres etapas. Primero, entrevista telefónica sobre variables sociodemográficas, estilos de vida y morbilidad diagnosticada; segundo, visita al domicilio para obtener muestras de sangre y orina; tercero, nueva visita al domicilio para antropometría, medir presión arterial, recoger historia dietética electrónica y con un cuestionario estructurado evaluar las conductas alimentarias.

Los resultados de esta tesis doctoral muestran que la evidencia sobre la relación entre las conductas alimentarias y la obesidad aún es escasa e inconsistente, tanto en niños como en adultos. A pesar de ello, se observó una asociación entre las conductas alimentarias relacionadas con la obesidad y un mayor consumo de alimentos sólidos con elevada densidad energética, y de bebidas azucaradas y alcohólicas. Por otra parte, nuestros resultados muestran que sólo alrededor de la mitad de los españoles con diabetes tiene una dieta acorde con las recomendaciones dietéticas de la *European Association for the Study of Diabetes* (EASD), de la *American Diabetes Association* (ADA) y con la dieta mediterránea. Es más, la falta de diferencias entre la dieta de los diabéticos diagnosticados y los no diagnosticados sugiere deficiencias del sistema sanitario en el manejo de esta patología. Además, el principal problema de ingesta nutricional de los pacientes con diabetes e hipertensión arterial es la elevada ingesta de azúcar, sal y grasas saturadas. Tanto en diabéticos como hipertensos, las principales fuentes de sodio fueron el pan, los embutidos curados, los embutidos cocidos y las sopas. Las fuentes más importantes de grasas saturadas fueron los quesos curados, la bollería, las carnes rojas, los embutidos curados y la leche entera.

Y por último, los grupos que más contribuyeron a la ingesta de azúcares añadidos fueron el azúcar añadido directamente al café y otras bebidas, la bollería, los refrescos y el yogur entero. Es de destacar que unos pocos alimentos representan una parte sustancial de esta ingesta excesiva, en consecuencia, unos simples cambios en la dieta podrían traducirse en una mejora importante de la calidad nutricional de la dieta de estos pacientes.

ACRÓNIMOS Y ABREVIATURAS

ADA	**:**	American Diabetes Association.
DM	**:**	Diabetes Mellitus.
EASD	**:**	European Association for the Study of Diabetes.
ECV	**:**	Enfermedad Cardiovascular.
ENRICA	**:**	Estudio de Nutrición y Riesgo Cardiovascular de España.
FRCV	**:**	Factor de Riesgo Cardiovascular.
HTA	**:**	Hipertensión.
IMC	**:**	Índice de Masa Corporal.
NHIE	**:**	National Health Interview and Examination Surveys.
OMS	**:**	Organización Mundial de la Salud.
PA	**:**	Presión Arterial.

1. INTRODUCCIÓN

1.1 Planteamiento del problema de las enfermedades cardiovasculares

Las enfermedades cardiovasculares (ECV) son un conjunto de trastornos del corazón y de los vasos sanguíneos (http://www.who.int/cardiovascular_diseases/es/). Entre ellas se encuentran las cardiopatías coronarias, las enfermedades cerebrovasculares, las arteriopatías periféricas, las cardiopatías reumáticas, las cardiopatías congénitas, las trombosis venosas profundas y las embolias pulmonares (http://www.who.int/mediacentre/factsheets/fs317/es/index.html). Éste grupo de enfermedades corresponde a las rúbricas I00-I99 de la décima revisión de la Clasificación Internacional de Enfermedades (CIE 10) (Piédrola Gil et al., 2008).

Estas enfermedades son una importante causa de carga de enfermedad en España (Villar et al, 2007) y en otros países desarrollados, incluyendo Europa (Allender et al, 2008) y Estados Unidos de América (Roger et al, 2011). Siendo la principal causa de muerte en nuestro país. Sin embargo, a pesar de que la mortalidad por las ECV ha mostrado una tendencia decreciente en los países desarrollados, lo cual se ha visto confirmado en nuestro país, su prevalencia ha aumentado en las últimas décadas, entre otras razones debido al aumento de la esperanza de vida de la población y las mejoras en su tratamiento y su prevención (Baena-Díez et al., 2010).

1.1.1 Factores de riesgo cardiovascular

La inflamación crónica de baja intensidad en las arterias, la aterotrombosis y la hipertensión arterial mantenida a lo largo de la vida, son mecanismos patogénicos de las ECV. Éstos empiezan a actuar desde las etapas más tempranas de la vida, de modo que en niños se han observado elevaciones de la presión arterial, disfunción endotelial y estrías grasas. Consolidándose este proceso a lo largo de los años, manifestándose finalmente como enfermedad clínica habitualmente en la edad adulta y/o vejez (Piédrola Gil et al., 2008).

Estas enfermedades poseen un origen multifactorial (Baena-Díez et al., 2005). Un factor de riesgo cardiovascular (FRCV) es una conducta o característica biológica que aumenta la probabilidad de padecer o morir de ECV (Piédrola Gil et al., 2008).

Los FRCV pueden ser no modificables como la edad y el sexo, o modificables como el tabaquismo, la hipertensión arterial (HTA), la hipercolesterolemia y la diabetes mellitus

(DM). Sin embargo, el impacto de los FRCV sobre la aparición de ECV es muy diferente entre países con niveles similares de desarrollo (Baena-Díez et al., 2005).

Por otro lado, la urbanización, industrialización y globalización que acompañan la transición económica traen consigo cambios en los modos de vida que propician las ECV. Surgiendo factores de riesgo como la dieta inadecuada, el consumo de tabaco, y la inactividad física (http://www.who.int/cardiovascular_diseases/priorities/es/).

1.1.2 ¿Cómo reducir la carga de las enfermedades cardiovasculares?

La Organización Mundial de la Salud (OMS) ha identificado intervenciones costo-eficaces en la prevención y control de las ECV, cuyo empleo es factible incluso en entornos de escasos recursos.

Realizar actividades físicas de forma regular, evitar la inhalación del humo del tabaco, consumir una dieta rica en frutas y verduras, y baja en sodio, alimentos grasos y alimentos azucarados, conservar un peso corporal saludable, y evitar la ingesta excesiva de alcohol, son conductas que reducen el riesgo de ECV.

Para prevenir y controlar las ECV son necesarias acciones globales e integradas. Entre ellas podemos encontrar las políticas globales para el control del tabaco, impuestos que favorezcan la reducción de la ingesta de alimentos ricos en grasas, azúcares y sal, la creación de vías para peatones y bicicletas con el fin de fomentar la actividad física, y el suministro de comidas saludables en los comedores escolares. Por otro lado, las estrategias integradas se centran en los principales factores de riesgo comunes a varias ECV. Existen varias intervenciones disponibles, inclusos algunas pueden ser aplicadas por profesionales sanitarios no médicos en centros cercanos al cliente. Dichas intervenciones son costo-eficaces, tienen gran impacto y son prioritarias para la OMS. Por ejemplo, la identificación en atención primaria de personas en riesgo mediante la aplicación de tablas de predicción de riesgos específicos, o el uso de combinaciones de fármacos que ayuden a reducir el riesgo de recurrencia y muerte.

La OMS considera que los gobiernos deben seguir invirtiendo en la prevención y detección precoz mediante programas de prevención y control de las enfermedades no transmisibles, y en particular de las ECV (http://www.who.int/mediacentre/factsheets/fs317/es/index.html).

1.2 Sobrepeso y obesidad

El sobrepeso y la obesidad son desórdenes nutricionales frecuentemente observables en la población general, con un alarmante incremento en sus prevalencias tanto en países industrializados como subdesarrollados (Koletzko et al., 2010). Se definen como una acumulación anormal o excesiva de grasa que puede ser perjudicial para la salud. Con la finalidad de identificarlos en la población adulta se utiliza el índice de masa corporal (IMC), que es un indicador simple de la relación entre el peso y la talla (kg/m^2) (http://www.who.int/mediacentre/factsheets/fs311/es/). De acuerdo al IMC, la OMS hace la siguiente clasificación:

- Sobrepeso: IMC ≥ 25.
- Obesidad: IMC ≥ 30. (Gutiérrez-Fisac et al., 2004; http://www.who.int/mediacentre/factsheets/fs311/es/;)

En España la prevalencia del sobrepeso es superior al 30% llegando al 40% en algunos estudios. Sin embargo, la prevalencia de la obesidad oscila entre el 11% y el 23% (Aranceta-Bartrina et al., 2005; Rodríguez-Rodríguez et al., 2011; Banegas et al., 2011).

El sobrepeso y la obesidad son el quinto factor principal de riesgo de defunción en el mundo. Cada año fallecen por su causa aproximadamente 2,8 millones de personas adultas. Asimismo, el 44% de la carga de diabetes, el 23% de la carga de cardiopatías isquémicas y entre el 7% y el 41% de la carga de algunos cánceres son atribuibles a ellas (http://www.who.int/mediacentre/factsheets/fs311/es/).

Para realizar recomendaciones prácticas para el control de la obesidad, es necesario identificar sus determinantes. Una de las causas fundamentales del sobrepeso y la obesidad es un desequilibrio energético entre calorías consumidas y las gastadas. En el mundo, se ha producido un aumento en la ingesta de alimentos hipercalóricos ricos en grasa, sal y azúcares pero pobres en vitaminas, minerales y otros micronutrientes, y un descenso en la actividad física como resultado de la naturaleza cada vez más sedentaria de muchas formas de trabajo, de los nuevos modos de desplazamiento y de una creciente urbanización (http://www.who.int/mediacentre/factsheets/fs311/es/). Por otra parte, numerosos estudios no han logrado establecer una relación clara entre la obesidad y la ingesta de energía y macronutrientes y los tipos concretos de alimentos consumidos (Hu et al., 2008), lo que ha llevado a prestar cada vez más atención a conductas alimentarias que implican varios alimentos simultáneamente en diferentes contextos sociales (Rodríguez et al., 2006). Algunas de las conductas alimentarias de mayor interés, porque su frecuencia ha aumentado de forma paralela a la epidemia de obesidad en los países occidentales, son saltarse el desayuno (Siega-Riz et al., 1998), consumir snacks (Jahns et al., 2001; Zizza et al., 2001), comer fuera de casa, consumir comida rápida (Nielsen et a., 2002), e ingerir grandes porciones de comida (Nielsen et al., 2003).

1.3 Hipertensión arterial

La HTA constituye una elevación crónica de la presión arterial (PA). Se define como la presencia mantenida de cifras de PA sistólica iguales o superiores a 140 mmHg, PA diastólica igual o superior a 90 mmHg, o ambas (de la Sierra et al., 2008).

La HTA es muy frecuente. En España su prevalencia en adultos es de aproximadamente un 33%, llegando a más del 40% en edades medias y a cifras superiores al 60% en mayores de 60 años, por lo que afecta a unos 10 millones de personas adultas (de la Sierra et al., 2008; Banegas et al., 2011).

Esta enfermedad es una de las principales causas de ECV y muerte en el mundo (Lopez et al., 2007; Lawes et al, 2008). Además, del tratamiento farmacológico, se ha demostrado que una dieta saludable, la actividad física y el control del peso son efectivo en el control de la presión arterial y en la reducción del riesgo cardiovascular (Elmer et al., 2006; Dickinson et al., 2006).

1.4 Diabetes

La Diabetes Mellitus es un grupo de enfermedades metabólicas caracterizadas por hiperglicemia, consecuencia de defectos en la secreción y/o en la acción de la insulina. La hiperglicemia crónica se asocia en el largo plazo con daño, disfunción e insuficiencia de diferentes órganos especialmente de los ojos, riñones, nervios, corazón y vasos sanguíneos. La American Diabetes Association definió a la diabetes mellitus como una glucemia en ayunas ≥126 mg/dl (ADA, 2012).

La prevalencia de la diabetes mellitus en España es de aproximadamente un 6% (Masiá et al., 2004; Gabriel et al., 2008; Banegas et al., 2011). En el contexto internacional, en adultos blancos de Estados Unidos en 2008, la prevalencia de diabetes era 10% en varones y 8% en mujeres (Roger et al, 2011).

La diabetes conlleva un importante riesgo de enfermedades cardiovasculares, tanto por sí sola como combinada con otros factores de riesgo tales como la hipertensión arterial y la dislipidemia. Las personas con diabetes tienen entre dos y cuatro veces más riesgo de padecer enfermedades cardiovasculares que la población general, y el 70-80% de las personas con diabetes mueren por enfermedades cardiovasculares (Alberti el al., 2007)

La terapia nutricional es un componente integral de la prevención y manejo de la diabetes mellitus. Además, cuando se combina con la intervención sobre estilos de vida (e.g. actividad física, cesación tabáquica) puede mejorar aún más los resultados clínicos y metabólicos (ADA, 2012).

1.5 Terapia nutricional

La terapia nutricional consiste en corregir los desequilibrios nutricionales ocasionados por diversas patologías. Incluye comprobar el estado nutricional de los individuos y dar los alimentos o nutrientes apropiados para tratar las afecciones causadas por diversas enfermedades, tales como diabetes, cardiopatías, y cáncer entre otras. Abarca cambios sencillos en el régimen alimentario de una persona, o la alimentación intravenosa o con sonda (http://www.cancer.gov/diccionario?cdrid=482428).

La terapia nutricional es un componente integral de la prevención y manejo de la presión arterial y los niveles de glucosa (Mann et al., 2004; Appel et al., 2006; Bantle et al., 2008). De hecho, en ensayos clínicos la terapia nutricional ha demostrado producir una reducción sustancial de la presión arterial sistólica y diastólica (Appel et al., 1997; Sacks et al., 2001). Así como también mejoras mantenidas en la hemoglobina glicada (ADA, 2012). Además, cuando la terapia nutricional se combina con la intervención sobre otros estilos de vida (e.g. actividad física, cesación tabáquica) puede mejorar aún más los resultados clínicos y metabólicos (ADA, 2012).

En consecuencia, varias sociedades científicas han elaborado recomendaciones para el manejo nutricional de la hipertensión (Mancia et al., 2007) y la diabetes (Connor et al., 2003; Mann et al., 2004; Bantle et al., 2008).

1.6 Conductas alimentarias

Cuando hablamos de conducta alimentaria nos estamos refiriendo al comportamiento normal relacionado con los hábitos de alimentación y a la selección de los alimentos que se ingieren, advirtiendo al respecto que en forma general los patrones alimentarios se forman y se aprenden (Gómez, 2002).

Se han observado conductas alimentarias comunes en la población, que pueden tener consecuencias perjudiciales en la salud de las personas (Rampersaud et al., 2005). Asimismo, estas conductas alimentarias pueden ser factores de riesgo para el sobrepeso y la obesidad, es por esto que las principales guías para el control de peso recomiendan moderar o evitar ciertos comportamientos alimentarios que podrían llevar a la ganancia de peso, tales como saltarse el desayuno, comer en restaurantes de comida rápida, comprar snacks. Del mismo modo, existen comportamientos alimentarios que se promueven para lograr una alimentación saludable y controlar así el peso, entre ellos se encuentran seleccionar alimentos bajos en calorías, quitar la grasa de la carne antes de comerla, comer lento, comer sentado a la mesa sin distracciones como la TV, y seleccionar la cantidad de comida antes de sentarse a la mesa entre otros (Dapcich et al., 2004; Katzen et al., 2006; MSC, 2007; Gidding 2009).

1.7 Estudio de Nutrición y Riesgo Cardiovascular en España - ENRICA

El ENRICA es un estudio nacional con entrevista y examen (National Health Interview and Examination Surveys - NHIES) realizado en una muestra representativa de la población española. Los objetivos del estudio ENRICA fueron determinar la frecuencia y la distribución de los principales componentes de la historia natural de la ECV en España, incluidos la dieta y otros factores de riesgo conductuales, los factores de riesgo biológicos, la lesión temprana de órganos diana y la morbilidad diagnosticada. También se examinaron los conocimientos y actitudes de los españoles acerca de los factores de riesgo de ECV y su control. Además, el estudio documentó las desigualdades de sexo y socioeconómicas en el tratamiento y el control de los principales factores de riesgo y en las actitudes de la población sobre el riesgo de ECV (Rodríguez-Artalejo et al., 2011).

2. JUSTIFICACIÓN DEL ESTUDIO

Las ECV constituyen una de las principales causas de muerte entre los españoles (Baena-Díez et al., 2010). Además, son una importante causa de carga de enfermedad en España (Villar et al., 2007), Europa (Allender et al., 2008) y Estados Unidos de América (Roger et al., 2011). Para controlar las ECV se necesitan estrategias poblacionales e intervenciones clínicas, que prioricen a aquellos pacientes de alto riesgo (Rose, 2001). Para implantar de forma racional y evaluar ambos tipos de intervenciones se necesita disponer de información sobre la historia natural de la ECV en la población (Rodríguez-Artalejo et al., 2011).

La obesidad por su elevada frecuencia y por sus consecuencias sobre la salud es considerada un importante problema de salud pública (Freedman, 2011). Por lo que se hace necesario identificar sus determinantes, para poder definir recomendaciones prácticas que permitan su control. No obstante, en la mayoría de los estudios no se ha logrado establecer una relación clara entre la obesidad y la ingesta energética, los macronutrientes y tipos específicos de alimentos (Hu, 2008). Esta situación ha llevado a que cada vez se preste más atención a diversas conductas alimentarias, cuya frecuencia ha ido en aumento de forma paralela a la epidemia de la obesidad. Entre ellas encontramos consumir snacks (Jahns et al., 2001; Zizza et al., 2001), comer fuera de casa, consumir comida rápida (Nielsen et al., 2002), e ingerir tamaños de ración grandes (Nielsen et al., 2003). A pesar de ello, las revisiones que examinan la asociación entre las conductas alimentarias y el exceso de peso son escasas (Rampersaud et al., 2005; Timlin et al., 2007; Moreno et al., 2008; Rosenheck, 2008; Szajewska et al., 2010; Koletzko et al., 2010). Es más, la gran mayoría de los artículos incluidos en ellas han sido publicados antes del 2008, lo que avala la necesidad de llevar a cabo una revisión sistemática al respecto, ya que desde entonces ha habido un gran aumento de la producción científica en este campo.

Por otra parte, entre estas conductas alimentarias, podemos encontrar algunas que podrían llevar al aumento de peso. De hecho las principales guías para el control del peso recomiendan evitar o moderar algunos de estos comportamientos, como por ejemplo saltarse el desayuno, comer en restaurantes de comida rápida, comprar snacks, entre otras. A la vez, existen conductas que se promueven para lograr una alimentación saludable y el control del peso, entre ellas están seleccionar alimentos bajos en calorías, quitar la grasa de la carne antes de comerla, comer lento, comer sentado a la mesa sin distracciones como la TV, y seleccionar la cantidad de comida antes de sentarse a la mesa (Dapcich et al., 2004; Katzen et al., 2006; MSC, 2007; Gidding et al., 2009). Se ha observado que los individuos que poseen un mayor número de conductas alimentarias relacionadas con la obesidad tienen una mayor intesta energética total (Mesas et al., 2012). Sin embargo, la información acerca de las posibles formas en que estas conductas alimentarias relacionadas con la obesidad conducen a una mayor ingesta energética total es escasa. Por lo que examinar el modo en que estas conductas llevan a una mayor ingesta de energía se hace necesario.

Por otro lado, la DM y la HTA son dos importantes problemas de salud pública debido a su elevada frecuencia y su asociación con el aumento del riesgo de ECV, discapacidad prematura y muerte (van Dieren et al., 2010; Lim et al. 2012). En España, el 12% de la poblaciónes diabética (Soriguer et al., 2012) y un tercio es hipertensa (Banegas et al., 2012). La terapia nutricional es clave para el manejo de los niveles de glucosa y de presión arterial en estos individuos (Mann et al. 2004; Appel et al., 2006; Bantle et al. 2008). En algunos ensayos clínicos se ha observado que la terapia nutricional lleva a mejoras mantenidas de la hemoglobina glicada (ADA, 2012). Por otro lado, la dieta mediterránea también ha demostrado reducir el riesgo de diabetes (Salas-Salvado et al., 2010). De hecho facilita la pérdida de peso (Esposito et al., 2011), el control glucémico y el control de los principales FRCV asociado a la DM (Esposito et al., 2010). A pesar de ello, solo unos pocos estudios de base poblacional han examinado la dieta de los diabéticos (Eilat-Adar et al., 2008; Resnick et al., 2006). Es más, en Europa los estudios han reportado un bajo cumplimiento de las recomendaciones nutricionales (Toeller et al. 1996; Virtanen et al., 2000; GNSDNu, 2004; Thanopoulou et al., 2004; GSEDNu, 2006; Helmer et al., 2008; Rivallese et al., 2008; Nöthlings et al., 2011) y no todos ellos son representativos de los diabéticos en la población general (Toeller et al. 1996; Virtanen et al., 2000; GNSDNu, 2004; GSEDNu, 2006; Rivallese et al., 2008; Nöthlings et al., 2011). Por último, los estudios se realizaron hace al menos 10 años, por lo que pueden no representar la dieta de los diabéticos en la actualidad. Lo que hace esencial examinar la dieta de una muestra representativa de diabéticos españoles y valorar su grado de acuerdo con las recomendaciones nutricionales.

Conjuntamente a lo anterior, se ha observado que la dieta de los hipertensos españoles posee un bajo acuerdo con las principales recomendaciones nutricionales, debido principalmente a una excesiva ingesta de sodio, grasas saturadas y azúcares añadidos (León-Muñoz et al., 2012). Por otro lado, hasta donde conocemos, ningún estudio ha llevado a cabo un análisis exhaustivo de las principales fuentes alimentarias de nutrientes en una población de hipertensos o diabéticos en Europa. Por lo que es fundamental identificar las principales fuentes alimentarias de estos tres nutrientes en una muestra representativa hipertensos y diabéticos españoles.

3. HIPÓTESIS Y OBJETIVOS

3.1 Hipótesis

En relación a las conductas alimentarias:

1. Algunas conductas alimentarias, entre ellas saltarse el desayuno, comida o cena, comer rápido, comer hasta saciarse, comer fuera de casa, consumir comida rápida, número de comidas diarias, comer entre horas, comer de forma irregular y comprar comida para llevar, se asocian al exceso de peso.

2. Algunas conductas alimentarias comunes en la población, tales como comprar snacks en máquinas expendedoras, comer alimentos precocinados, en restaurantes de comida rápida o mirando la TV, no planear cuanto comer antes de sentarse a la mesa, no elegir alimentos bajos en grasa y no quitar la grasa de la carne ni la piel del pollo antes de comerlos, se asocian al consumo de raciones de mayor tamaño y de alimentos con elevada densidad energética. Asimismo, se asocian con un mayor número de ocasiones de ingesta, y con una mayor ingesta de bebidas azucaradas y alcohólicas.

En relación a las terapias nutricionales:

1. El acuerdo de la dieta de los diabéticos adultos españoles con las recomendaciones nutricionales de la *European Association for the Study of Diabetes (EASD), American Diabetes Association (ADA)* y con la dieta mediterránea es bajo.

2. En la población de diabéticos e hipertensos adultos españoles las principales fuentes alimentarias de sodio son el pan, los embutidos y las sopas. Las fuentes más importantes de grasas saturadas son el queso curado, la bollería, la carne roja, los embutidos y la leche entera. En el caso de los azúcares añadidos, son el azúcar añadido directamente al café u otras bebidas, la bollería, los refrescos azucarados y el yogurt entero.

3.2 Objetivos

En relación a las conductas alimentarias:

1. Examinar la asociación entre las siguientes conductas alimentarias: saltarse el desayuno, comida o cena, comer rápido, comer hasta saciarse, comer fuera de casa, consumir comida rápida, número de comidas diarias, comer entre horas, comer de forma irregular y comprar comida para llevar, y el exceso de peso en la población general a través de una revisión sistemática de publicaciones escritas en inglés, español y portugués.

2. Analizar la asociación entre el tamaño de la ración consumida y las siguientes conductas alimentarias: comprar snacks en máquinas expendedoras, comer alimentos precocinados, en restaurantes de comida rápida o mirando la TV, no planear cuanto comer antes de sentarse a la mesa, no elegir alimentos bajos en grasa y no quitar la grasa de la carne ni la piel del pollo antes de comerlos. Además, examinar la asociación entre estas conductas alimentarias y la densidad energética de los alimentos consumidos, el número de ocasiones de ingestas diaria y el consumo de bebidas azucaradas y alcohólicas, en una muestra representativa de la población adulta española durante 2008-2010.

En relación a las terapias nutricionales:

1. Examinar la dieta de una muestra representativa de la población adulta española con diabetes durante 2008-2010 y valorar el grado de acuerdo con las recomendaciones nutricionales de la EASD, ADA, y la dieta mediterránea.

2. Identificar las principales fuentes alimentarias de sodio, grasas saturas y azúcares añadidos en una muestra representativa de personas hipertensas y diabéticas en España 2008-2010.

4. METODOLOGÍA

4.1 Artículo 1

Se realizó una revisión sistemática para evaluar la asociación de las conductas alimentarias y el exceso de peso.

Búsqueda bibliográfica

Se realizó una búsqueda en PubMed hasta el 31 de Diciembre de 2010, usando las siguientes palabras clave en el título y en el resumen: “obesity”, “obese”, “weight gain”, “weight change”, “overweight”, “fatness”, “metabolic syndrome”, y los siguientes términos relacionados con las conductas alimentarias: “eating habits”, “eating patterns”, “eating behavior”, “skipping breakfast”, “skipping lunch”, “skipping dinner”, “eating away from home”, “fast food”, “takeaway food”, “eating frequency”, “snacking”, “nibbling”, “irregular meals”, “portion size” y “meal size”. También se buscaron publicaciones en las listas de referencias de los artículos recuperados de PubMed.

Selección de estudios y extracción de datos

Se incluyeron estudios observacionales y experimentales, publicados en inglés, español o portugués. Se excluyeron los artículos con protocolos de estudio, los reportes de series de casos, y los estudios realizados sólo con personas con exceso de peso, comedores compulsivos, o diabéticos; también se excluyeron estudios sin información sobre las variables de interés, y los que no analizaron o no presentaron estimadores cuantitativos sobre las asociaciones de estudio.

Dos investigadores (AEM y MMP) seleccionaron los estudios y extrajeron los datos de forma independiente, y las discrepancias se resolvieron por consenso entre ellos, o en conferencia con un tercero (FRA).

Evaluación de la calidad

En los estudios transversales se valoró el porcentaje de respuesta, en los estudios de cohortes la tasa de seguimiento, y en los de casos-control si los controles se habían seleccionado de forma apropiada para representar la población de la que surgen los casos. En los estudios experimentales se valoró sin fueron randomizados, si se enmascaró la intervención, y las pérdidas en el seguimiento. En todos los estudios se valoró si el peso corporal, la talla y/o la circunferencia de cintura fueron autorreportadas o basadas en mediciones, y el grado de ajuste por potenciales confusores. Para ello, los estudios se clasificaron en cuatro categorías: (0) análisis crudo; (+) ajuste por edad, sexo y algún indicador de nivel socioeconómico, ya fuera propio o de los padres en el caso de los niños; (++) ajuste adicional por actividad física ó sedentarismo, y por consumo de tabaco en adultos; y (+++) ajuste adicional por ingesta total de energía ó por otras conductas alimentarias.

Análisis de datos

Los resultados se presentaron para cada conducta alimentaria por separado. Además, se presentan de para cada tipo de estudio (transversal, longitudinal) y para cada grupo de edad (niños y/o adolescentes, adultos). La gran heterogeneidad en las poblaciones y diseños de estudio, en la definición y clasificación de las variables de interés, en las medidas de efecto utilizadas, y en los resultados a través de los estudios aconsejó no combinar los resultados mediante técnicas meta-analíticas. En las conclusiones de esta revisión se priorizaron los resultados de estudios longitudinales con buen control de potenciales confusores (nivel ++ ó +++).

4.2 Artículo 2

Se tomaron datos del estudio transversal ENRICA para evaluar la adherencia de la dieta de los individuos diabéticos españoles a las recomendaciones nutricionales de la EASD, ADA y dieta mediterránea.

Participantes

De los 12.948 participantes del estudio ENRICA, se seleccionó a los 609 individuos que conocían su condición de diabético, que tenían una dieta en rango válido (hombres >800 a <5000 kcal/día; mujeres >500 a <4000 kcal/día), y que tenían información completa en todas las variables de estudio.

Diabetes mellitus

Se definió diabetes mellitus como glucemia ≥126 mg/dl1 o estar en tratamiento antidiabético. Debido a que la terapia nutricional se realiza sólo en diabéticos diagnosticados, los análisis de datos incluyeron sólo a los diabéticos que respondieron afirmativamente a la pregunta “Have you ever been told by the doctor that you had diabetes or elevated blood sugar?”.

Para valorar el control glucémico se usó la HbA1c, determinada en una muestra sanguínea por cromatografía HPLC (analizador ADAMS A1c HA-8160, Arkray). Buen control gluémico glucémico se definió como HbA1c <7%.1

Dieta

La calidad de la dieta de los diabéticos se evaluó mediante el grado de acuerdo con las recomendaciones nutricionales de la EASD (Mann et al., 2004) y la ADA (Bantle et al., 2008). A partir de las 12 principales recomendaciones nutricionales de la EASD, se desarrolló un score en el que se otorgaba 1 punto si se cumplía la recomendación y 0 puntos si no se cumplía. El score final se calculó como la suma de los puntos de cada recomendación (rango 0-12) y se consideró acuerdo moderado una puntuación igual o superior al valor intermedio (≥6 puntos). Se construyó un score similar que valoró el acuerdo con las recomendaciones de la ADA, el score de ADA tuvo un rango de 0 a 6, y se consideró acuerdo moderado a tener ≥3 puntos. El acuerdo con el patrón de dieta mediterránea se evaluó con el Mediterranean Diet Adherence Screener (MEDAS) (Schroder et al., 2011) desarrollado por el estudio PREDIMED (Estruch et al., 2006). El score MEDAS tiene un rango de 0 a 14, una puntuación ≥7 se consideró como acuerdo moderado con la dieta mediterránea.

Análisis estadístico

El análisis estadístico fue principalmente descriptivo calculándose el porcentaje de diabéticos diagnosticados, y su intervalo de confianza (IC) 95%, cuya dieta era acorde con las recomendaciones de EASD, ADA y dieta mediterránea. Para resumir la asociación entre las variables socio-demográficas, de estilos de vida y clínicas y el acuerdo con las recomendaciones dietéticas, se calcularon odds ratios (OR) y sus IC 95% mediante regresión logística con ajuste por sexo y edad. El análisis estadístico se realizó con los procedimientos survey de Stata v.11., porque permiten tener en cuenta el diseño muestral complejo de este estudio (USA: Texas Press, 2011).

4.3 Artículo 3

Se tomaron datos del estudio ENRICA para identificar las principales fuentes de sodio, ácidos grasos saturados y azúcares añadidos en individuos hipertensos y diabéticos españoles.

Participantes

De los 12.948 participantes del estudio ENRICA, se seleccionaron a 2.323 hipertensos y a 635 diabéticos, que conocían su condición de hipertenso o diabético, que tenían una dieta en rango válido (hombres >800 a <5000 kcal/día; mujeres >500 a <4000 kcal/día), y que tenían información completa en todas las variables de estudio.

Hipertensión arterial

Se definió hipertensión como PA sistólica ≥140 mmHg y/o PA diastólica ≥90 mmHg, o estar en tratamiento con fármacos antihipertensivos. Para el análisis se seleccionó a los sujetos hipertensos que contestaron afirmativamente a la pregunta "Have you ever been told by the doctor that you had hypertension, also called high blood pressure?".

Diabetes mellitus

Se definió diabetes mellitus como glucemia ≥126 mg/dl o estar en tratamiento antidiabético. Para el análisis de los datos se seleccionó a los sujetos diabéticos que contestaron afirmativamente a la pregunta "Have you ever been told by the doctor that you had diabetes or elevated blood sugar?".

Dieta

Los participantes de este estudio reportaron información para un total de 880 alimentos, que fueron clasificados en grupos homogéneos según su composición nutricional. Para el análisis de los azúcares añadidos se seleccionó a los 181 alimentos que los contenían, que fueron clasificados en grupos homogéneos según su composición nutricional. La ingesta de sodio, grasas saturadas y azúcares añadidos se calculó utilizando tablas de composición de alimentos y la información contenida en las etiquetas de algunos alimentos (Jiménez et al., 1990; Farrán et al., 2004; Moreiras et al., 2007; Ortega et al., 2007; USDA 2007).

Análisis estadístico

El análisis fue principalmente descriptivo. La contribución de cada grupo de alimentos a la ingesta de los nutrientes estudiados se obtuvo como: [nutriente objetivo aportado por un grupo de alimentos específico / nutriente aportado por todos los grupos de alimentos para todos los individuos de la muestra] x 100. Considerándose finalmente sólo a aquellos grupos que contribuyeron con un 1% o más del nutriente estudiado. Los análisis se realizaron teniendo en cuenta el diseño complejo de la muestra, usando el paquete estadístico SAS v. 9.2 (Cary NC: SAS Institute, 2004).

4.4 Artículo 4

Se tomaron datos del estudio ENRICA para evaluar la asociación entre las conductas alimentarias y la ingesta de alimentos con mayor densidad energética, bebidas azucaradas y bebidas alcohólicas.

Participantes

De los 12.948 participantes del estudio ENRICA, se seleccionaron a los 11.546 individuos que tenían información completa en todas las variables de estudio y que tenían una dieta en rango válido (hombres >800 a <5000 kcal/día; mujeres >500 a <4000 kcal/día).

Conductas alimentarias

Se usó información de 8 conductas alimentarias que habían mostrado asociación con una mayor ingesta energética.

Las conductas alimentarias analizadas fueron:

1. Planea cuanto comer antes de sentarse a la mesa.
2. Consume alimentos precocinados o enlatados.
3. Compra chocolates u otros snacks en máquinas expendedoras.
4. Come en restaurantes de comida rápida.
5. Selecciona alimentos bajos en calorías.
6. Quita la grasa de la carne antes de comerla.
7. Quita la piel del pollo antes de comerlo.
8. Come o cena viendo TV.

Dieta

La historia dietética de ENRICA recoge la dieta habitual durante el año anterior, con preguntas relativas a todas las comidas posibles a lo largo del día (Rodríguez-Artalejo et al., 2011). De esta historia se obtuvo información de las ocasiones de ingesta diaria de los españoles (desayuno, almuerzo, comida, merienda, cena y snacks). Del tamaño de las porciones de los alimentos sólidos, de la densidad energética de los alimentos sólidos consumidos y de la ingesta de bebidas azucaradas y alcohólicas.

Análisis estadístico

La asociación entre cada conducta alimentaria y el tamaño de la porción, la densidad energética y el número de ocasiones de ingesta de alimentos sólidos, y el consumo de bebidas azucaradas y alcohólicas se resumió con coeficientes β y sus IC 95%. Los análisis fueron ajustados por sexo, edad, nivel educacional, consumo de tabaco, tipo de ocupación, actividad física en el tiempo libre, horas gastadas viendo TV, obesidad general, obesidad abdominal, hipertensión, diabetes e hipercolesterolemia. . El análisis estadístico se realizó con los procedimientos survey de Stata v.11., porque permiten tener en cuenta el diseño muestral complejo de este estudio (USA: Texas Press, 2011).

5. ARTÍCULO 1: Selected eating behaviours and excess body weight: a systematic review

Conductas alimentarias y exceso de peso: una revisión sistemática.

(obesity reviews 2012; 106–135)

Antecedentes: La relación entre la obesidad y la ingesta de macronutrientes y alimentos específicos es incierta. Por lo tanto, hay un creciente interés en algunas conductas alimentarias, porque ellas pueden reflejar el efecto conjunto de varios alimentos y nutrientes, y así aumentar la probabilidad de encontrar una conexión con la obesidad. Este estudio examina la asociación entre algunas conductas alimentarias y el exceso de peso en la población general.

Métodos: Revisión sistemática de publicaciones escritas en Inglés, Español o Portugués identificadas en un búsqueda en PubMed hasta el 31 de Diciembre de 2010. Se incluyeron estudios observacionales y experimentales. Se excluyeron protocolos de investigación, reportes de series de casos, y estudios conducidos sólo entre individuos con exceso de peso, comedores compulsivos o diabéticos. Dos investigadores seleccionaron independientemente los estudios y extrajeron los datos.

Resultados: Se incluyeron 153 artículos, 73 de los cuales han sido publicados desde 2008. Sólo 30 estudios tenían un diseño prospectivo; de esos, 15 habían sido ajustados por variables sociodemográficas, actividad física y energía o ingesta de alimentos. Más aún, la definición de conductas alimentarias varió substancialmente entre los estudios. Encontramos sólo una pequeña o inconsistente evidencia de una relación entre el exceso de peso y saltarse el desayuno, la frecuencia diaria de las comidas, comer entre horas, comer de forma irregular, comer fuera de casa, comer comida rápida, comprar comida para llevar, consumo de grandes porciones, comer hasta saciarse y comer rápido.

Conclusión: Esta revisión refleja la dificultad en la medición del comportamiento humano, y sugiere que se necesita un enfoque más sistemático para la captura de los efectos de las conductas alimentarias en el peso.

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Etiology and Pathophysiology

Selected eating behaviours and excess body weight: a systematic review

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Summary

The relationship between obesity and the intake of macronutrients and specific foods is uncertain. Thus, there is growing interest in some eating behaviours because they may reflect the joint effect of several foods and nutrients and, thus, increase the likelihood of finding a link to obesity. This study examined the association between selected eating behaviours and excess weight in the general population throughout a systematic review of publications written in English, Spanish or Portuguese identified in a PubMed search up to 31 December 2010. We included 153 articles, 73 of which have been published since 2008. Only 30 studies had a prospective design; of these, 15 adjusted for sociodemographic variables, physical activity and energy or food intake. Moreover, definitions of eating behaviours varied substantially across studies. We found only small or inconsistent evidence of a relationship between excess weight and skipping breakfast, daily eating frequency, snacking, irregular meals, eating away from home, consumption of fast food, takeaway food intake, consumption of large food portions, eating until full and eating quickly. In conclusion, this review highlights the difficulty in measuring human behaviour, and suggests that a more systematic approach is needed for capturing the effects of eating behaviours on body weight.

Keywords: Eating behaviours, obesity, overweight, systematic review.

obesity reviews (2012) **13**, 106–135

Introduction

Obesity is an important public health problem in both children and adults because of its high frequency and important health consequences (1–3). To formulate practical recommendations for the control of obesity, its determinants must be identified. However, the scientific literature has not shown a clear relation between obesity and intake of energy and macronutrients and specific types of food consumed (4). Thus, progressively more attention has been paid to eating behaviours, because they may reflect the joint effect of a number of foods and nutrients and, thus, increase the likelihood of finding a link to obesity (5). Moreover, if eating behaviours are shown to be causally related to obesity, they may represent practical strategies for obesity prevention above and beyond the simple advice to 'eat less and exercise more'.

This article systematically reviews the literature in children and adults from the general population on the relationship between obesity and the following eating behaviours: skipping breakfast, daily meal frequency, snacking, irregular eating, eating away from home, eating fast food, eating takeaway food, portion size, eating until full and eating quickly. We used several criteria to select the study behaviours. First, evidence that they have increased in frequency parallel with the obesity epidemic in Western countries; this is the case of skipping breakfast (6), eating snacks (7,8), eating away from home (9), eating fast food

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(9) and eating large portions of food (10). Second, some behaviours are frequently overlapped, and it was reasonable to obtain a comprehensive picture of their effect on obesity. For instance, meal frequency, irregular eating and snacking are associated with skipping breakfast and other main meals; and eating takeaway food is associated with eating away from home, consumption of fast food and eating large food portions. Third, some very specific behaviours that have made part of the traditional advice for healthy eating and weight control, such as to avoid eating until full or eating quickly. And fourth, the existence of reviews on these topics that would merit an update. We found several reviews where most of the articles included were published before 2008 (11–16), and since then many new studies have been published. Thus, this review includes information from 153 articles, 73 of which have been published since 2008.

Methods

The recommendations of the meta-analysis of observational studies in epidemiology statement (17) and the preferred reporting items for systematic reviews and meta-analyses statement (18) have been followed where applicable.

Literature search

A PubMed search up to 31 December 2010 was made using the following keywords in the title and abstract: 'obesity', 'obese', 'weight gain', 'weight change', 'overweight', 'fatness' and 'metabolic syndrome', and the following terms related to eating behaviours: 'eating habits', 'eating patterns', 'eating behavior', 'skipping breakfast', 'skipping lunch', 'skipping dinner', 'eating away from home', 'fast food', 'takeaway food', 'eating frequency', 'snacking', 'nibbling', 'irregular meals', 'portion size' and 'meal size'. The complete search strategy is presented in Supporting Information Table S1 (online supporting information). The reference lists of articles retrieved from PubMed were also reviewed.

Study selection and data extraction

We included observational and experimental studies published in English, Spanish or Portuguese. We excluded articles describing study protocols, reports of case series and studies made only on patients with excess weight, binge eaters or diabetics. Studies with no information on the variables of interest were also excluded, as were those that either did not analyze or did not present quantitative estimates of the study associations.

Two investigators (Arthur E. Mesas and Maritza Muñoz-Pareja) independently selected the studies and extracted the data, and discrepancies were resolved by consensus between them, or in consultation with a third investigator (Fernando Rodriguez-Artalejo).

Quality assessment

In cross-sectional studies we evaluated the response rate; in cohort studies, the follow-up rate; and in case-control studies, the comparability of cases and controls. In experimental studies we evaluated whether they were randomized, if the intervention was blinded, and the losses to follow-up. In all studies, we assessed whether body weight, height and/or waist circumference were self-reported or based on measurements, and the degree of adjustment for potential confounders. For this, purpose studies were classified into four categories: (0) only crude analysis; (+) adjustment for age, gender and some indicator of socioeconomic level, either of the subject or of the parents in the case of children; (++) additional adjustment for physical activity or sedentarism and for smoking in adults; and (+++) additional adjustment for total energy intake or other eating behaviours.

Data analysis

The results are presented separately for each eating behaviour. They are also presented by age group (children and/or adolescents, adults) and by study type (cross-sectional, longitudinal). The use of meta-analytic techniques was not appropriate because studies were very heterogeneous with regard to study populations and designs, definition and classification of the variables of interest, the effect measures used and results. In the conclusions of this review, priority is given to the results of the studies with greater ability to show causal associations: longitudinal studies with good control of confounders (++ or +++).

Results

Figure 1 shows the flow of articles through this systematic review. The PubMed search identified 5,200 articles, and 84 articles were found in other sources. Of the total of 5,284 articles identified, 4,939 were excluded because their title and abstract did not refer to the study associations. Of the 345 articles retrieved for critical reading, 192 were excluded because they did not provide information useful for this review. The complete list of the articles excluded and the reasons for each is presented in the supporting information. Thus, the final review included 153 articles (19–171) on the association between eating behaviour and excess weight (151 articles) or the metabolic syndrome (two articles).

Table 1 presents the characteristics of the 153 articles selected. The oldest article was published in 1964 (61), and 73 have been published since 2008. The United States of

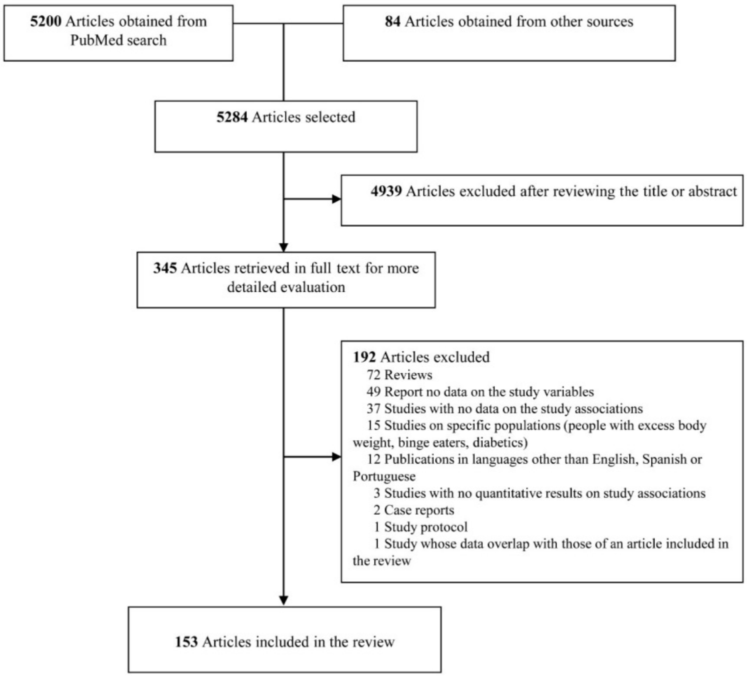

Figure 1 Flow of publications through the study.

America (USA), the Nordic countries and Spain were the countries with the largest number of studies (45, 15 and 11 articles, respectively). Participants in 126 studies included both men and women; in 16 studies, only women were included; and in 11, only men. Most studies (89 articles) examined the association between eating behaviours and excess weight in children and adolescents, generally in school samples. Three studies presented data for children or adolescents as well as for their parents (26,60,95). Sixty-one articles described studies in adults in the general population. Of these, 29 articles included participants aged 60 or more, but only three studies examined the association between eating behaviours and excess weight (61,168) or the metabolic syndrome (144) specifically in older adults.

The studies were methodologically heterogeneous. The most frequent design was cross-sectional (116 articles). The median response rate was 81% (range, 30.4–99.6%), based on the 69 articles reporting this information. The 30 prospective studies had a median follow-up of 5 years (range, 1–15 years), and the median retention rate, according to the information available in 19 articles, was 85% (range, 67.3–94.8%). Four case-control studies were also included (78,120,126,150). All of these used gender and age as a matching criterion; furthermore, in one study the socioeconomic level of obese subjects (cases) was considered for the selection of non-obese subjects (controls) (126). Three experimental studies were included (28,62,99). The oldest one was a non-randomized trial comparing body weight (index of proportionality) with number of meals per day (three, five or seven meals per day). The authors of this article reported losses during 1 year (mostly due to illness), but did not present the final retention rate (62). The other two were laboratory experiments, in which repeated measures were obtained of how long it took obese and non-obese children to eat (28,99).

Of the 10 eating behaviours considered in this review, 103 articles presented results for only one behaviour, 37 for two behaviours and eight for three behaviours, and five studies gave results for four eating behaviours. The most frequently studied behaviour was skipping breakfast, lunch or dinner (73 articles), followed by snacking (44 articles), daily meal frequency (39 articles), consumption of fast food (26 articles), eating away from home (17 articles), portion size (10 articles), eating quickly (eight articles), eating take-away food (four articles), eating until full (three articles) and eating irregular meals (three articles).

The most frequent outcome variables were overweight/obesity (93 studies) and body mass index (BMI) (46 studies). Some studies also examined weight gain (35–37,49,89,125,132,137,162), percentage of body fat (21,59,112,134,161,168), abdominal obesity (27,75,82,86,92,125,145,146) and the metabolic syndrome (143,144). The anthropometric data were based on measurements in 117 articles, were self-reported in 34 articles and were estimated by observers in one article (169); one study, however, did not report whether the data were measured or self-reported (148).

Table 1 Methodological characteristics of the 153 articles included in this review

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Affenito *et al.* (2005) (19)	Female/2,379/9–10 years/United States of America	Cohort/9 years/96% at 2 years, 94% at 3 years, 91% at 4 years, 82% at 7 years, 89% at 10 years of follow-up	Public and parochial schools (Berkeley and Cincinnati) and community based (Westat)	BMI (kg m^{-2})/measured weight and height	Days of breakfast eating (0–3 d, annually measured in a 3-d food diary)
al-Isa (1999) (20)	Both genders/842/<18–>23 years/Kuwait	Cross-sectional/85%	University students	Obesity (grade 1: BMI >25 kg m^{-2}; grade 2: BMI >30 kg m^{-2})/measured weight and height	Daily eating frequency (eating regularly one, two or three meals per day)
Al-Rethaiaa *et al.* (2010) (21)	Male/357/18–24 years/Kingdom of Saudi Arabia	Cross-sectional/96.5%	University students	BMI categories (kg m^{-2}); body fat percent categories (low, normal, high, very high)/measured weight and height.	Take breakfast (rarely, one to two, three to four times per week, always); daily eating frequency (one, two, three, four times per day); snacking frequency (taking snacks apart from regular meals: rarely, one to two, three to four times per week, always); take meals regularly (always regular, irregular)
Albertson *et al.* (2007) (22)	Female/2,371/9–10 years/United States of America	Cohort/9 years/96% at 2 years, 94% at 3 years, 91% at 4 years, 82% at 7 years, 89% at 10 years of follow-up	Public and parochial schools (Berkeley and Cincinnati) and community based (Westat)	BMI *Z* scores (BMI cut-offs by CDC growth charts)/measured weight and height	Days of breakfast eating (0–3 d, annually measured in a 3-d food diary)
Amin *et al.* (2008) (23)	Male/1,139/10–14 years/Kingdom of Saudi Arabia	Cross-sectional/response rate not reported	Public primary schools (urban and rural)	Overweight (BMI ≥85th percentile); obesity (BMI ≥95th percentile) (BMI cut-offs by IOTF growth charts)/measured weight and height	Taking breakfast at home (yes, no); eating away from home (>3 times/week, ≤3 times/week)
Amosa *et al.* (2001) (24)	Female/80/18–27 years/New Zealand	Cross-sectional/97.6%	Healthy volunteers (European and Polynesian women)	Obesity (BMI >30 kg m^{-2})/measured weight and height	Skipping breakfast (1–7 d/week)
Andersen *et al.* (2005) (25)	Both genders/3,139/8–13 years/Norway	Cross-sectional/86% in 1986, 80–85% in 2000	Primary and secondary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/self-reported weight and height	Eating breakfast (≤2, 3–5, 6–7 d/week)
Ayala *et al.* (2008) (26)	Both genders/708 parents and children/mean age (±SD): 35 years (±7.5 years) for parents; 6 years (±0.9 years) for children/United States of America-Mexico border	Cross-sectional/response rate not reported	Elementary schools predominantly (≥70%) frequented by children of Latino families	Overweight (BMI ≥25 to <30 kg m^{-2} for parents; BMI ≥95th percentile for children) (BMI cut-offs by CDC growth charts); obesity (BMI ≥ 30 to <40 kg m^{-2} for parents)/measured weight and height	Eating away from home: at relatives', neighbours' and friends' homes; at restaurants (fast foods, buffet and sit-down restaurants) (≥1 times/week, lower frequency)
Barba *et al.* (2006) (27)	Both genders/3,668/6–11 years/Italy	Cross-sectional/71%	Schools	BMI (kg m^{-2}); waist circumference (cm)/measured weight, height and waist circumference	Daily eating frequency (meals/snacks) (≤3, 4, ≥5 times/d)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Barkeling *et al.* (1992) (28)	Both genders/43/11 years/Sweden	Experimental study/97.7% completed the study	Laboratory	Obesity (BMI ≥23.5 kg m^{-2})/measured weight and height	Rate of consumption (g/min)
Barton *et al.* (2005) (29)	Female/2,379/9–10 years/United States of America	Cohort/9 years/retention rate not reported	Public and parochial schools (Berkeley and Cincinnati) and community based (Westat)	BMI Z score; at risk of overweight (BMI ≥85th percentile, using BMI cut-offs by CDC growth charts)/measured weight and height	Days of breakfast eating (0–3 d, measured with annual 3-d food records)
Bellisle *et al.* (1995) (30)	Both genders/16,486/mean age: 21.4 years/21 European countries	Cross-sectional/response rate not reported	Non-medical university students	BMI (kg m^{-2})/self-reported weight and height	Number of meals per day (1, 2, 3, 4, >4 meals/d); snacking frequency (0, 1, 2, 3, >3 times/d)
Berg *et al.* (2009) (31)	Both genders/3,610/25–74 years/Sweden	Cross-sectional/42%	Population based (urban areas)	Obesity (BMI ≥30 kg m^{-2})/measured weight and height	Skipping breakfast or lunch (yes, no); daily eating frequency (one to eight meals per day); eating away from home (yes, no); portion size (size 1–9, based on four pictures)
Berkey *et al.* (2003) (32)	Both genders/14,586/9–17 years/United States of America	Cohort/3 years/M: 89.5%, F: 94.1% to at least one of the follow-up surveys	Children who were offspring of Nurses' Health Study II participants	Change in BMI (kg m^{-2}) per year/self-reported weight and height	Breakfast frequency (never, 1 to 2, 3 to 4, ≥5 times/week).
Berteus Forslund *et al.* (2002) (33)	Female/177/37–60 years/Sweden	Cross-sectional/obese participants: 86%, reference population: 58%	Urban population (obese participants from an intervention study and reference participants from a population-based study)	Obesity (BMI ≥30 kg m^{-2})/measured weight and height	Number of meals/d; number of snack meals/d (times/d).
Berteus Forslund *et al.* (2005) (34)	Both genders/5,351/30–60 years/Sweden	Cross-sectional/obese participants: 95.3%, reference population: 55.7%	Urban population (obese participants from an intervention study and reference participants from a population-based study)	Obesity (BMI ≥30 kg m^{-2})/measured weight and height.	Daily eating frequency (1 to ≥12 times/d); snacking frequency (none to ≥3 times/d)
Bes-Rastrollo *et al.* (2006) (35)	Both genders/7,194/mean age: 41 years/Spain	Cohort/2.4 years/>90%	University graduates (Universidad de Navarra)	Weight gain (difference in kg from baseline)/self-reported weight	Fast food intake (hamburgers, sausages and pizza) (yes, no)
Bes-Rastrollo *et al.* (2010a) (36)	Both genders/9,182/≥18 years/Spain	Cohort/4.4 years/94.8% at 2 years of follow-up	University graduates (Universidad de Navarra)	Weight change (change in g/year of follow-up: as a continuous variable and as changing ≥2 kg/year); incident overweight /obesity (participants with BMI <25 kg m^{-2} at baseline and BMI ≥25 after follow-up)/self-reported weight and height	Eating away from home (never to 3 times/month, 1 time/week, ≥2 times/week).

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Bes-Rastrollo *et al.* (2010b) (37)	Both genders/10,162/mean age: 39 years/Spain	Cohort/4.6 years/88% at 5 years	University graduates (Universidad de Navarra)	Weight gain (≥3 kg/year)/self-reported weight	Snacking (yes, no); fast food intake (hamburgers, sausages and pizza) (yes, no).
Bezerra and Sichieri (2009) (38)	Both genders/56,178/25–65 years/Brazil	Cross-sectional/79.6%	Population based	Overweight (25 kg m^{-2} ≤ BMI < 30 kg m^{-2}); obesity (BMI ≥30 kg m^{-2})/measured weight and height	Eating deep-fried snacks away from home; eating out of home; eating fast foods (≥1 time/week)
Bibiloni *et al.* (2010) (39)	Both genders/1,231/12–17 years/Spain	Cross-sectional/82%	Population based	Overweight (85th ≤ BMI < 97th percentiles); obesity (BMI ≥97th percentile) (BMI cut-offs by WHO growth charts)/measured weight and height.	Breakfast habit (yes, occasionally, no); number of meals (1 to 3, 4, ≥5 meals/d)
bin Zaal *et al.* (2009) (40)	Both genders/661/12–17 years/United Arab Emirates	Cross-sectional/response rate not reported	Preparatory and secondary schools	Obesity (BMI ≥85th percentile) (BMI cut-offs by WHO growth charts)/measured weight and height.	Breakfast frequency (never, frequently, always); snacking (never, frequently, always); fast food consumption (never, frequently, always)
Binkley *et al.* (2000) (41)	Both genders/16,103/≥18 years/United States of America	Cross-sectional/response rate not reported	Population based	Body weight (kg); overweight (definition not reported)/self-reported weight and height	Restaurant intake; fast food intake (percentage of total g/24-h period)
Bishwalata *et al.* (2010) (42)	Both genders/3,356/12–19 years/India	Cross-sectional/88.6%	Schools	BMI (kg m^{-2})/measured weight and height	Eating between meals (yes, no)
Boo *et al.* (2010) (43)	Both genders/240/age not reported/Malaysia	Cross-sectional/78.2%	Medical students	Overweight/obesity (BMI ≥23 kg m^{-2})/measured weight and height	Breakfast eating (yes, no; median number of days having breakfast); daily eating frequency (interquartile range); consumed snacks (yes, no; median number of snacks per day); consumed fast food (yes, no; median number of fast food per week)
Boutelle *et al.* (2002) (44)	Both genders/8,330/mean age: 14 years/United States of America	Cross-sectional/83%	Public schools	Overweight (BMI 85th–95th percentile; BMI >95th percentile) (BMI cut-offs by NHANES I growth charts)/self-reported weight and height	Eating breakfast (yes, no)
Bowman and Vinyard (2004) (45)	Both genders/9,872/≥20 years/United States of America	Cross-sectional/80%	Population based	Overweight (BMI ≥25 kg m^{-2})/self-reported weight and height	Fast food consumption (yes, no, self-reported in two different survey days)
Bralic and Kovacic (2005) (46)	Female/328/13–18 years/Croatia	Cross-sectional/response rate not reported	Comprehensive schools	BMI (kg m^{-2})/measured weight and height	Skipping breakfast, lunch and dinner (skipped occasionally or routinely, did not skip)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Casey *et al.* (2008) (47)	Both genders/826/≥18 years/United States of America	Cross-sectional/62.5%	Population based (rural population)	Obesity (BMI ≥30 kg m^{-2})/self-reported weight and height	Eating away from home (never, occasionally, sometimes, often); eating at fast food restaurant (never, occasionally, sometimes, often)
Cho *et al.* (2003) (48)	Both genders/16,452/≥18 years/United States of America	Cross-sectional/response rate not reported	Population based (NHANES III)	BMI (kg m^{-2})/measured weight and height	Skipping breakfast (yes, no)
Coakley *et al.* (1998) (49)	Male/19,478/42–77 years/United States of America	Cohort/4 years/70.5% from baseline to 6 years (follow-up study period from 2-year to 6-year survey)	Health professionals	Body weight change (kg) (difference from baseline)/self-reported weight	Snacking (eating between meals) (yes, no)
Colapinto *et al.* (2007) (50)	Both genders/4,966/10–11 years/Canada	Cross-sectional/51.1%	Public schools	Overweight (BMI cut-offs by IOTF growth charts)/measured weight and height	Portion size (three-dimensional graduated models for French fries, meat, fish, chicken, cooked vegetables, potato chips)
Craig *et al.* (2010) (51)	Both genders/1,233/3–16 years/Scotland	Cross-sectional/66%	Population based	Overweight (BMI ≥85th percentile and <95th percentile); obesity (BMI ≥ 95th percentile) (BMI cut-offs taken from specific British growth charts)/measured weight and height	Snack food consumption (g/d) (assessed by FFQ)
Croezen *et al.* (2009) (52)	Both genders/25,176/13–16 years/the Netherlands	Cross-sectional/94.8%	Secondary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/self-reported weight and height	Skipping breakfast (0, 1–2, 3–4, 5–6, 7 d/week)
de Gouw *et al.* (2010) (53)	Both genders/31,228/10–18 years/Czech Republic	Cross-sectional/response rate not reported	Schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast (yes, no); eating lunch (yes, no); mid-morning snacking (yes, no); afternoon snacking (yes, no); besides meal snacking (yes, no)
Deshmukh-Taskar *et al.* (2010) (54)	Both genders/9,659/9–18 years/United States of America	Cross-sectional/response rate not reported	Population based (NHANES 1999–2006)	Overweight (BMI ≥85th and <95th percentiles); obesity (BMI ≥95th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Skipping breakfast (yes, no)
Dialektakou and Vranas (2008) (55)	Both genders/811/14–20 years/Greece	Cross-sectional/response rate not reported	Public high schools	BMI (kg m^{-2}); overweight and obesity (BMI ≥25 kg m^{-2})/measured weight and height	Skipping breakfast (yes, no)
Dubois *et al.* (2006) (56)	Both genders/1,520/3–5 years/Canada	Cross-sectional/98%	Pre-schools	Overweight (BMI ≥95th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Eating breakfast (every day, not every day)
Dubois *et al.* (2009) (57)	Both genders/1,549/3–5 years/Canada	Cross-sectional/79.7%	Pre-schools	Overweight (BMI ≥95th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Eating breakfast (every day, not every day)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Duffey *et al.* (2007) (58)	Both genders/3,394/18–30 years/United States of America	Cohort/3 years/81% at 7 years (baseline) and 79% at 10 years (end of follow-up)	Population based (urban areas)	Change in BMI (kg m^{-2})/measured weight and height	Eating at restaurants; fast food intake (increased, decreased or maintained frequency during follow-up)
Duncan *et al.* (2008) (59)	Both genders/1,229/5–11 years/New Zealand	Cross-sectional/response rate not reported	Primary schools	Overfat status (body fat ≥25% in boys, ≥30% in girls)/measured hand-to-foot bioelectrical impedance analysis	Breakfast eating (never, 1–2 d/week, 3–4 d/week, ≥5 d/week); fast food intake (never, 1–2 d/week, 3–4 d/week, ≥5 d/week)
Elfhag *et al.* (2010) (60)	Both genders/1,258 families (mother, father and child)/mother: mean age of 40.4 years; father: mean age of 42.4 years; children's age: 10–13 years/Sweden	Cross-sectional/33.5%	Population based	Overweight (BMI ≥25 kg m^{-2} for parents; BMI cut-off points by IOTF growth charts for children)/self-reported weight and height	External eating (score from a specific eating behaviour questionnaire)
Fabry *et al.* (1964) (61)	Male/379/60–64 years/Czechoslovakia	Cross-sectional/86.1%	Population based	Overweight: (10% overweight: calculated according to the index 100 × body weight [kg]/height [cm] above 100 cm)/measured weight and height	Frequency of meals; snacking (eating meals ≤3, 3–4, 3–4 with an additional snack between meals, 3–4 with an additional at bedtime, ≥5 times/d)
Fabry *et al.* (1966) (62)	Both genders/226/6–16 years/Czechoslovakia	Experimental study/1-year follow-up with controlled daily eating frequency/retention rate not reported	Boarding schools	Index of proportionality (by subtracting the deviation of height from that of body weight) (BMI cut-offs taken from specific Czech growth charts)/measured weight and height	Daily eating frequency (three, five, seven meals per day)
Field *et al.* (2004) (63)	Both genders/14,977/9–14 years/United States of America	Cohort/3 years/retention rate not reported	Children who were offspring of Nurses' Health Study II participants	Change in BMI *Z* score per year (BMI cut-offs by CDC growth charts)/self-reported weight and height	Snack food intake (yes, no)
Fiore *et al.* (2006) (64)	Both genders/1,890/12–16 years/United States of America	Cross-sectional/response rate not reported	Population based (NHANES III)	At risk or obese (BMI ≥85th percentile) year (BMI cut-offs by NHANES growth charts)/measured weight and height	Eating breakfast (rarely/never, some days, every day)
Fonseca *et al.* (1998) (65)	Both genders/391/15–17 years/Brazil	Cross-sectional/92.2%	Private schools	Overweight (BMI >90th percentile) (BMI cut-offs taken from specific Brazilian growth tables)/measured weight and height	Breakfast eating (almost never, <3, 3–6 times/week, daily)
Francis *et al* (2003) (66)	Female/173/5 years/United States of America	Cohort/4 years/retention rate not reported	Pre-school children	Change in BMI (difference from baseline; BMI cut-offs by IOTF growth charts)/measured weight and height	Snacking frequency (zero to four times per day)
Frank *et al.* (2009) (67)	Both genders/4,545/25–64 years/Canada	Cross-sectional/30.4%	Population based	BMI (kg m^{-2})/self-reported weight and height	Eating at fast food restaurant (≥1-d over the 2-d diary, no)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Franko *et al.* (2008) (68)	Female/2,375/9–10 years/United States of America	Cohort/10 years/96% at 2 years, 94% at 3 years, 91% at 4 years, 82% at 7 years, 89% at 10 years of follow-up	Public and parochial schools (Berkeley and Cincinnati) and community based (Westat)	BMI *Z* score; overweight (BMI ≥95th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Daily meal frequency (≥3 meals/d or lower frequency in a 3-d food diary)
French *et al.* (2000) (69)	Female/891/20–45 years/Sweden	Cohort/3 years/89.3%	Community volunteers	Body weight (kg)/measured weight and height	Fast food restaurant use (times/week)
French *et al.* (2001) (70)	Both genders/4,746/11–18 years/United States of America	Cross-sectional/77.1%	Public schools	BMI (kg m^{-2}); overweight (BMI >95th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Frequency of fast food restaurant use (never, 1, 2, 3, 4, ≥5 times/week)
Gigante *et al.* (1997) (71)	Both genders/1,035/20–69 years/Brazil	Cross-sectional/90.4%	Population based	Obesity (BMI ≥30 kg m^{-2})/measured weight and height	Number of daily meals (≤3, >3 meals/d)
Gikas *et al.* (2003) (72)	Both genders/513/15–18 years/Greece	Cross-sectional/response rate not reported	High schools	Overweight/obesity (BMI ≥85th percentile) (BMI cut-offs taken from a table derived from nine large epidemiological studies in the United States of America)/measured weight and height	Skipping breakfast (yes, no); snacking (yes, no)
Goto *et al.* (2010) (73)	Male/4,634/mean age: 21.5 years/Japan	Cohort/1 years/retention rate not reported	University students	BMI change ≥5% (difference in kg m^{-2} from baseline)/measured weight and height	Frequently skipping breakfast (yes, no)
Grujić *et al.* (2009) (74)	Both genders/3,854/≥20 years/Serbia	Cross-sectional/response rate not reported	Population based	Overweight and obesity (BMI ≥25 kg m^{-2})/measured weight and height	Breakfast eating (always, never/sometimes)
Halkjaer *et al.* (2009) (75)	Both genders/42,696/50–64 years/Denmark	Cohort/5 years/83.9%	Population based	Waist circumference changes (difference in cm after follow-up)/measured weight and height	Snack consumption (kcal/d)
Hamaideh *et al.* (2010) (76)	Both genders/824/14–17 years/Jordan	Cross-sectional/84%	Schools	BMI (kg m^{-2})/measured weight and height	Eating breakfast regularly (yes, no)
Harding *et al.* (2008) (77)	Both genders/6,599/11–13 years/United Kingdom	Cross-sectional/81%	Schools	Overweight and obesity (BMI cut-offs by IOTF growth) charts)/Measured weight and height.	Skipping breakfast (always/sometimes, rarely)
He *et al.* (2000) (78)	Both genders/1,322/0.1–6.9 years/China	Case control/response rates not reported	Population based	Obesity (weight that exceeded the standard weight for height, age and gender by more than 20% or, equivalently, a height-adjusted weight that is 120% or more than standard)/measured weight and height	Daily eating frequency (>3 meals/d); eating speed determined by either the parents or the kindergarten teacher who was taking care of the child (number of chews per swallow: ≤2 as fast, 3–5 as middle, <5 as slow eating speed)
Henriquez Sanchez *et al.* (2008) (79)	Both genders/1,002/12–14 years/Spain	Cross-sectional/57.2%	Secondary schools	Overweight (BMI ≥85th percentile); obesity (BMI ≥97th percentile) (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast (yes, no)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Hingorjo *et al.* (2009) (80)	Both genders/192/18–21 years/Pakistan	Cross-sectional/response rate not reported	Dentistry students	Overweight (BMI ≥23.0 to 24.9 kg m^{-2}); obesity (BMI ≥25 kg m^{-2})/measured weight and height	Skipping breakfast (yes, no); snacking (yes, no)
Hirschler *et al.* (2009) (81)	Both genders/330/mean age: 8.9 years/Argentina	Cross-sectional/96.3%	Elementary schools	Overweight and obesity (BMI ≥85th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Skipping breakfast (yes, no)
Holmback *et al.* (2010) (82)	Both genders/3,009/47–68 years/Sweden	Cross-sectional/response rate not reported	Population based	Overweight (BMI 25 to <30 kg m^{-2}); obesity (BMI ≥30 kg m^{-2}); severe central obesity (WC ≥102 cm in men and ≥88 cm in women)/measured weight and height	Daily eating frequency (≤3, 4–5, ≥6 times/d)
Howarth *et al.* (2007) (83)	Both genders/2,685/20–90 years/United States of America	Cross-sectional/51.0%	Population based	BMI (kg m^{-2})/self-reported weight and height	Daily eating frequency (≤3, 3.5–6 and >6 meals/d); snacking frequency (number of snack intake per day)
Huang *et al.* (2004) (84)	Both genders/1,995/3–19 years/United States of America	Cross-sectional/response rate not reported	Population based	BMI percentiles (BMI cut-offs by CDC growth chart)/self-reported weight and height	Daily eating frequency (times/day); snack frequency (times/day); meal portion size (g); snack portion size (g)
Huang *et al.* (2010) (85)	Both genders/15,340/18–64 years/Taiwan	Cross-sectional/80.6%	Population based	Obesity (BMI ≥27 kg m^{-2})/self-reported weight and height	Eating breakfast (≥2 d/week as breakfast consumers, never or about once/week or less often as breakfast skippers)
Isacco *et al.* (2010) (86)	Both genders/278/6–10 years/France	Cross-sectional/65%	Schools	BMI *Z* score; waist circumference (cm); skin-fold thickness/measured weight, height, waist circumference and skin-fold thickness	Skipping breakfast (every day, sometimes, never); snacking between meals (every day, sometimes, never)
Jeffery *et al.* (1998) (87)	Both genders/1,059/20–45 years/United States of America	Cohort/1 year/retention rate not reported	Healthy volunteers	BMI (kg m^{-2}); change in BMI (difference from baseline)/measured weight and height	Frequency of fast food consumption (day/week)
Jeffery *et al.* (2006) (88)	Both genders/1,033/mean age: 46.3 years/United States of America	Cross-sectional/response rate not reported	Population based (telephone survey)	BMI (kg m^{-2})/self-reported weight and height	Fast food eating (yes, no)
Kant *et al.* (1995) (89)	Both genders/7,147/25–74 years/United States of America	Cohort/8–10 years/retention rate not reported	Population based (NHANES I)	Weight change (difference in kg from baseline)/measured weight and height	Eating frequency (≤2, 3, 4, 5, 6, ≥7 meals or snacks/d)
Kant *et al.* (2008) (90)	Both genders/12,316/≥20 years/United States of America	Cross-sectional/76% (1999, 2000, 2003, 2004), 80% (2001, 2002)	Population based (NHANES 1999–2004)	BMI (kg m^{-2})/measured weight and height	Breakfast eating (yes, no)
Kapantais *et al.* (2011) (91)	Both genders/14,278/13–19 years/Greece	Cross-sectional/response rate not reported	Public schools	BMI (kg m^{-2})/measured weight and height	Breakfast skipping (<2 times/week, ≥2 times/week)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Keast *et al.* (2010) (92)	Both genders/5,811/12–18 years/United States of America	Cross-sectional/response rate not reported	Population based (NHANES 1999–2004)	Overweight/obesity (BMI ≥85th percentile) (BMI cut-offs by CDC growth charts); abdominal obesity (WC ≥90th percentile)/measured weight and height	Snacking (0, 1, 2, 3, ≥4 times/d)
Kent and Worsley (2009) (93)	Male/239/mean age: 44.8 years/Australia	Cross-sectional/response rate not reported	Urban population (advertising campaign)	Overweight and obesity (≥25 kg m^{-2})/measured weight and height	Eating between meals (snacking) (never/rarely, one to two times per day)
Kent and Worsley (2010) (94)	Both genders/1,527/mean age: 43–45 years/Australia	Cross-sectional/response rate not reported	Population based	BMI (kg m^{-2})/measured weight and height	Breakfast size (small, moderate, large)
Keski-Rahkonen *et al.* (2003) (95)	Both genders/5,448 adolescents with 16 years; 4,660 parents with ≥30 years/Finland	Cross-sectional/88% for boys, 93% for girls, 84% for fathers and 87% for mothers	Population based (cohorts of Finnish twins)	BMI (kg m^{-2})/elf-reported weight and height	Breakfast eating (≤1 time/week, a few times/week, every morning)
Keski-Rahkonen *et al.* (2007) (96)	Both genders/4,393/16 years/Finland	Cohort/8 years/>85% across all occasions	Population-based study of Finnish twins	Overweight (25 ≤ BMI < 27 kg m^{-2} and 27 ≤ BMI < 30 kg m^{-2}); obesity (BMI ≥ 30 kg m^{-2})/self-reported weight and height	Snacking patterns: snacking between meals, snacks replace meals (frequent: usually or often; not frequent: sometimes or rarely)
Kontogianni *et al.* (2010) (97)	Both genders/1,305/3–18 years/Greece	Cross-sectional/response rate not reported	Population based	BMI (kg m^{-2})/self-reported weight and height	Daily eating frequency (number of eating episodes per day)
Kosti *et al.* (2007) (98)	Both genders/2,008/12–17 years/Greece	Cross-sectional/95%	Public schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast (>5 times/week, ≤5 times/week); eating sweets and snacks (per one serving/week); consumption of foods outside of home (≥2 times/week, <2 times/week); daily eating frequency (number of meals per day)
Laessle *et al.* (2001) (99)	Both genders/80/8–12 years/Germany	Experimental study/100%	Laboratory experiment	Obesity (BMI >85th percentile) (BMI cut-offs taken from tables derived from NHANES I)/measured weight and height	Rate of eating (g/s^2) 250-g yoghurt of a preferred flavour (eating curves recorded by a modified version of the universal eating monitor)
Lagiou and Parava (2008) (100)	Both genders/633/10–12 years/Greece	Cross-sectional/response rate not reported	Primary schools	Overweight (BMI ≥85th percentile) (BMI cut-offs taken from specific Greek growth charts)/measured weight and height	Daily eating frequency (continuous variable)
Li *et al.* (2010) (101)	Both genders/1,792/11–17 years/China	Cross-sectional/99%	High schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast outside home (yes, no); snacking (yes, no); local fast food consumption (yes, no)
Liebman *et al.* (2003) (102)	Both genders/1,817/18–99 years/United States of America	Cross-sectional/51.5%	Population based (rural areas)	Overweight (BMI ≥25 kg m^{-2}); obesity (BMI ≥30 kg m^{-2})/self-reported weight and height	Eating supersized portions (more often, less often)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Lioret *et al.* (2009) (103)	Both genders/748/3–11 years/France	Cross-sectional/response rate not reported	Population based	Overweight and obesity (BMI cut-offs by IOTF growth charts)/self-reported weight and height	Portion size (total intake in g of items included in the food group and consumed during the week of the survey, divided by the number of eating occasions of these items)
Ma *et al.* (2003) (104)	Both genders/499/20–70 years/United States of America	Cross-sectional/response rate not reported	Population based (telephone survey)	Obesity (BMI ≥30 kg m^{-2})/measured weight and height	Eating breakfast (yes, no); daily eating frequency (≤3, ≥4 meals/d); consumption of foods away from home (frequency of each meal away from home in quartiles)
Maddah (2009a) (105)	Female/2,090/14–17 years/Iran	Cross-sectional/response rate not reported	Urban and rural high schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast (never, 1–2 times/week, ≥3 times/week)
Maddah *et al.* (2009b) (106)	Female/2,302/14–18 years/Iran	Cross-sectional/response rate not reported	Urban and rural high schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Skipping breakfast (yes, no)
Maddah and Nikooyeh (2010) (107)	Both genders/6,635/6–11 years/Iran	Cross-sectional/response rate not reported	Elementary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast (number of days per week)
Mahmood *et al.* (2010) (108)	Both genders/117/mean age: 29.7 ± 6.4 years/Pakistan	Cross-sectional/response rate not reported	Postgraduate trainee doctors	Obesity (BMI ≥23 kg m^{-2})/MEasured weight and height	Snacking between meals (yes, no); taking lunch outside home (yes, no)
Marin-Guerrero *et al.* (2008) (109)	Both genders/34,974/25–64 years/Spain	Cross-sectional/response rate not reported	Population based	Obesity (BMI ≥30 kg m^{-2})/self-reported weight and height	Eating breakfast, lunch or dinner (yes, no); daily eating frequency (one, two, three to four, several times per day); eating smaller-sized meals (several times, three to four times per day); eating breakfast, lunch or dinner away from home (yes, no)
Maruyama *et al.* (2008) (110)	Both genders/3,287/30–69 years/Japan	Cross-sectional/88.2%	Population based	Overweight (BMI ≥25 kg m^{-2})/measured weight and height	Self-reported eating until full (yes, no); self-reported speed of eating (very slow, slow, medium, fast, very fast)
McConahy *et al.* (2002) (111)	Both genders/1,039/2–5 years/United States of America	Cross-sectional/95.8%	Population based	Percentile body weight (<15th, 15th–85th, >85th percentile of the CDC growth charts)/self-reported weight and height	Daily eating occasions (meals per day); portion size (two non-consecutive 24-h dietary recalls)
McCrory *et al.* (1999) (112)	Both genders/73/18-80 years/United States of America	Cross-sectional/response rate not reported	Healthy volunteers	Body fatness (percent weight determined by hydrostatic weighing)/measured weight and height	Takeaway restaurant food consumption (times per month in the past 6 months)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
McDonald *et al.* (2009) (113)	Both genders/3,075/5–12 years/Colombia	Cross-sectional/81%	Public primary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Snacking (frequency of snacking pattern in quartiles); fast food intake (hamburger or hotdog) (≥1 time/week, lower frequency)
Mercille *et al.* (2010) (114)	Both genders/444/8–13 years/Canada	Cross-sectional/response rate not reported	Schools	BMI categories (overweight: BMI >95th percentile; at risk of overweight: BMI 85th–95th percentile; normal weight: 5th to <85th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Number of snacks (zero to three); fast food portion size (g)
Merten *et al.* (2009) (115)	Both genders/7,788/12–19 years/United States of America	Cohort/5 years/retention rate not reported	High schools	Obesity (BMI >95th percentile at baseline, BMI ≥30 kg m^{-2} after follow-up) (BMI cut-offs by CDC growth charts)/self-reported weight and height	Regular breakfast consumption (≥4 d/week, <4 d/week)
Moreno *et al.* (2005) (116)	Both genders/1,282/13–18.5 years/Spain	Cross-sectional/response rate not reported	Schools	BMI (kg m^{-2})/measured weight and height	Skipping breakfast (yes, no)
Mota *et al.* (2008) (117)	Both genders/886/13–17 years/Portugal	Cross-sectional/93.2%	Public secondary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Skipping breakfast (yes, no); daily eating frequency (≤3, 4, ≥5 meals/d)
Musaiger and Radwan (1995) (118)	Female/215/18–30 years/United Arab Emirates	Cross-sectional/response rate not reported	University students	Obesity (BMI ≥25 kg m^{-2})/measured weight and height	Eating breakfast, lunch and dinner (yes, no)
Nagel *et al.* (2009) (119)	Both genders/1,079/6–9 years/Germany	Cross-sectional/94%	Primary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast before school (yes, no)
Neutzling *et al.* (2003) (120)	Both genders/508/15–19 years/Brazil	Case control/response rates not reported	Private schools	Overweight (BMI ≥85th percentile); obesity (BMI ≥95th percentile) (BMI cut-offs taken from specific Brazilian growth charts)/measured weight and height	Eating breakfast (yes, no); daily eating frequency (>3 meals/d)
Nicklas *et al.* (2003) (121)	Both genders/1,562/10 years/United States of America	Cross-sectional (seven surveys combined)/response rate not reported	Schools	Overweight (BMI ≥85th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Number of meals per day; number of snacking (times per day)
Nicklas *et al.* (2004) (122)	Both genders/1,584/10 years/United States of America	Cross-sectional (seven surveys combined)/response rate not reported	Schools	Overweight (BMI ≥85th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Skipping breakfast (yes, no); daily eating frequency (<3, ≥3 meals/d; and as a continuous variable for total eating episodes); consuming meals away from home (yes, no)
Niemeier *et al.* (2006) (123)	Both genders/9,919/11–21 years/United States of America	Cohort/5 years/67.3% at 5 years	School based	BMI *Z* score (BMI cut-offs by CDC growth charts)/95% measured and 5% self-reported weight and height	Eating breakfast (number of days per week); eating at fast food (number of days per week)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Nishitani *et al.* (2009) (124)	Male/595/19–60 years/Japan	Cross-sectional/85.3%	Workers at a synthetic-fibre manufacturing plant	Obesity (BMI ≥25 kg m^{-2})/measured weight and height	Self-reported feeling of satiety (eating until full) (yes, no); self-reported eating 'style' or speed (fast, not fast)
Nooyens *et al.* (2005) (125)	Male/288/50–65 years/the Netherlands	Cohort/5 years/75%	Visitors of a health centre (except those with cancer, cardiovascular disease, diabetes and/or waist circumference <79 cm at baseline)	Change in body weight (kg); change in waist circumference (cm)/measured weight and waist circumference	Eating breakfast (yes, no)
Novaes *et al.* (2008) (126)	Both genders/100/6–8 years/Brazil	Case control/93.1% of the cases (obese) were paired with controls (normal weight)	Public and private schools	Overweight (BMI ≥85th and <95th percentiles); obesity (BMI ≥95th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Meal number (≤3, >6 meals/d); snacking patterns: substitute meals by snacks at dinner, snacking in commercial establishments (yes, no)
Omuemu and Omuemu (2010) (127)	Both genders/300/10–19 years/Nigeria	Cross-sectional/response rate not reported	Population based	Overweight (BMI ≥95th percentile); at risk of overweight (85th ≤ BMI < 95th percentile) (BMI cut-offs by CDC growth charts)/measured weight and height	Consumption of snacks (yes, no)
Ortega *et al.* (1998) (128)	Both genders/200/9–13 years/Spain	Cross-sectional/62.9%	Schools	Overweight and obesity (BMI ≥75th percentile from Spanish growth charts)/measured weight and height	Skipping breakfast (7-d food record)
Otsuka *et al.* (2006) (129)	Both genders/4,742/35–69 years/Japan	Cross-sectional/response rate not reported	Civil servants	BMI (kg m^{-2})/measured weight and height	Self-reported rate of eating (very slow, relatively slow, medium, relatively fast, very fast)
Panagiotakos *et al.* (2008) (130)	Both genders/700/10–12 years/Greece	Cross-sectional/83.5%	Schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Breakfast consumption (yes, no); daily eating frequency (1 or 2, 3, >3 meals/d)
Peixoto *et al.* (2007) (131)	Both genders/1,252/20–64 years/Brazil	Cross-sectional/72.9%	Population based	BMI (kg m^{-2})/measured weight and height	Daily eating frequency (<4, ≥4 meals/d)
Pereira *et al.* (2005) (132)	Both genders/3,031/18–30 years/United States of America	Cohort/15 years/74% at 15 years	Population based	Weight change (difference in kg from baseline)/measured weight and height	Fast food intake (<1, 1–2, >2 times/week)
Perez-Cueto *et al.* (2010) (133)	Both genders/2,437/20–70 years/Belgium, Denmark, Germany, Greece, Poland	Cross-sectional/response rate not reported	Population based (consumer survey)	Obesity (BMI ≥30 kg m^{-2})/self-reported weight and height	Giving preference to snacks over meals (yes, no)
Phillips *et al.* (2004) (134)	Female/196/8–12 years/ United States of America	Cohort/4 years after menarche/91%	Public schools	BMI *Z* score; percentage of body fat/measured weight and height	Daily servings of snack foods (times per day)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Pirincci *et al.* (2010) (135)	Both genders/3,642/6–11 years/Turkey	Cross-sectional/85.5%	Primary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Having breakfast (yes, no); eating fast foods (<2, ≥2 times/week)
Roseman *et al.* (2007) (136)	Both genders/4,049/11–14 years/United States of America	Cross-sectional/81.7%	Middle schools	Overweight (BMI ≥95th percentile); at risk of overweight (BMI ≥85th and <95th percentiles) (BMI cut-offs by CDC growth charts)/measured weight and height	Eating breakfast (did not eat; ate one to three, four to six times per day; every day)
Sanchez-Villegas *et al.* (2002) (137)	Both genders/3,847/≥18 years/Spain	Cross-sectional/response rate not reported	University graduates (Universidad de Navarra)	Weight change (kg) in the previous 5 years/self-reported weight and height	Snacking (yes, no)
Sandercock *et al.* (2010) (138)	Both genders/4,326/10–16 years/United Kingdom	Cross-sectional/88%	Schools	Obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Breakfast eating (always, sometimes, never)
Sanigorski *et al.* (2007) (139)	Both genders/1,944/4–12 years/Australia	Cross-sectional/50%	Kindergartens and primary schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Packaged snack consumption (≤1, 2–4, 5–6 times/week; 1, ≥2 times/d); fast foods (≤1, >1 time/week)
Schroder *et al.* (2007) (140)	Both genders/2,867/25–74 years/Spain	Cross-sectional/70.2%	Population based	BMI (kg m^{-2}); risk of obesity (definition not reported)/measured weight and height	Fast food intake (continuous variable in g/d; none or <1/month, 1–3 times/month, 1 time/week, >1 time/week)
Serra-Majem *et al.* (2006) (141)	Both genders/3,534/2–24 years/Spain	Cross-sectional/response rate not reported	Population based	Obesity (BMI ≥97th percentile from Spanish growth charts)/measured weight and height	Regular breakfast consumption (no, sometimes, yes); regular consumption of buns and snacks (<1, 1–4, ≥5 times/ week)
Shan *et al.* (2010) (142)	Both genders/19,517/6–18 years/China	Cross-sectional/99.6%	Population based	Overweight and obesity (BMI cut-offs taken from specific Chinese growth charts)/measured weight and height	Snack consumption (<1, 1–2, ≥3 times/week); Western fast food consumption (<1, 1–2, ≥3 times/week)
Shin *et al.* (2009) (143)	Male/7,081/≥30 years/South Korea	Cross-sectional/response rate not reported	Visitors of the Center for Cancer Prevention and Detection	Metabolic syndrome (having >3 of the following conditions: WC ≥102 cm; triglyceride level ≥150 mg dL^{-1}; HDL <40 mg dL^{-1}; systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg; impaired glucose tolerance with fasting glucose ≥110 mg dL^{-1})/measured weight, height and WC	Breakfast frequency (always, often, not at all); daily eating frequency (two, three times per day, irregular); irregular meals (two, three times per day, irregular); self-reported meal speed (slow, average, fast)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Sierra-Johnson *et al.* (2008) (144)	Both genders/3,607/60 years/Sweden	Cross-sectional/78%	Population based	Metabolic syndrome (having ≥3 of the following conditions: WC ≥102 cm in men and ≥88 cm in women; HDL <40 mg dL^{-1} in men and <50 mg dL^{-1} in women; triglycerides ≥150 mg dL^{-1}, systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg, fasting glucose ≥100 mg dL^{-1})/measured weight, height and WC	Eating regularly (never, sometimes as no; usually or always as yes)
Simmons *et al.* (2005) (145)	Both genders/1,454/mean age: 53 years/Australia	Cross-sectional/70.3%	Population based (urban and rural population)	Obesity (BMI ≥30 kg m^{-2}; WC ≥102 cm in men, ≥88 cm in women)/measured weight, height and WC	Takeaway food consumption (≥1 time/month, <1 time/month)
Smith *et al.* (2009) (146)	Both genders/2,862/26–36 years/Australia	Cross-sectional/61%	Population based	Overweight (BMI ≥25 kg m^{-2}); obesity (BMI ≥30 kg m^{-2}); abdominal obesity (WC ≥94 cm in men, ≥80 cm in women)/measured weight, height and WC	Takeaway food consumption (<2, ≥2 d/week)
Song *et al.* (2005) (147)	Both genders/4,218/≥19 years/United States of America	Cross-sectional/response rate not reported	Population based (NHANES)	BMI (kg m^{-2})/measured weight and height	Skipping breakfast (yes, no)
Summerbell *et al.* (1996) (148)	Both genders/220/13–91 years/United Kingdom	Cross-sectional/response rate not reported	Free-living population	BMI (kg m^{-2})/weight and height registry method not reported	Daily eating frequency (feeding frequency index)
Sun *et al.* (2009) (149)	Both genders/5,753/12–13 years/Japan	Cross-sectional/91.6%	Junior high schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Frequency of eating breakfast (daily, almost daily, sometimes, rarely); snacking (daily, almost daily, sometimes, rarely); self-reported eating volume (very large, large, normal, small); self-reported eating speed (very fast, fast, normal, slow)
Takahashi *et al.* (1999) (150)	Both genders/1,281/3 years/Japan	Case control/response rates not reported	Population based	Obesity (BMI ≥18 kg m^{-2})/measured weight and height	Snacking frequency (<3, ≥3 times/d); snacking regularity (regular, irregular)
Taveras *et al.* (2005) (151)	Both genders/14,355/9–14 years/United States of America	Cohort/3 years/boys: 72% at 1 year, 81% at 2 years, 68% at 3 years; girls: 81% at 1 year, 87% at 2 years, 79% at 3 years of follow-up	Children who were offspring of Nurses' Health Study II participants	BMI (kg m^{-2}); change in BMI (kg m^{-2}) over the follow up/Self-reported weight and height.	Fast food intake (fried food intake as a proxy of fast food intake; never or <1 time/week, 1–3, 4–7 times/week)
Terres *et al.* (2006) (152)	Both genders/960/15–18 years/Brazil	Cross-sectional/92.4%	Population based	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Skipping meals (yes, no)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Thompson *et al.* (2004) (153)	Female/101/8–12 years/United States of America	Cohort/10 years/retention rate not reported	Schools	Change in BMI *Z* score over the follow-up (BMI cut-offs by CDC growth charts)/measured weight and height	Takeaway food consumption (never, 1, ≥2 times/week)
Thompson *et al.* (2006) (154)	Female/101/8–12 years/United States of America	Cohort/10 years/retention rate not reported	Schools	Change in BMI *Z* score over the follow-up (BMI cut-offs by CDC growth charts)/measured weight and height	Daily eating frequency (0–4, 4–5, ≥6 times/d)
Thompson-McCormick *et al.* (2010) (155)	Female/523/15–20 years/Fiji	Cross-sectional/71%	Secondary schools	Overweight (15–19 years: BMI ≥85th percentile; 20 years: BMI ≥25 kg m^{-2}); obesity (15–19 years: BMI ≥95th percentile; 20 years: BMI ≥30 kg m^{-2})/measured weight and height	Breakfast skipping (0–7 d/week)
Timlin *et al.* (2008) (156)	Both genders/2,216/mean age: 14.9 years/United States of America	Cohort/5 years/77.4% at 5 years	Public middle and high schools	BMI (kg m^{-2}); change in BMI (kg m^{-2}) over the follow-up/measured weight and height	Breakfast frequency (daily, intermittent, never)
Toschke *et al.* (2005) (157)	Both genders/4,370/5–6 years/Germany	Cross-sectional/80%	Pre-schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Daily eating frequency (≤3, 4, ≥5 meals/d)
Toschke *et al.* (2009) (158)	Both genders/4,642/5–6 years/Germany	Cross-sectional/78%	Pre-schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Regular breakfast consumption (yes, no); daily eating frequency (≤3, 4, ≥5 meals/d); regular snacking sweet, crisps or related products watching television (yes, no)
Toyoshima *et al.* (2009) (159)	Male/1,080/≥40 years/Japan	Cohort/5 years/retention rate not reported	Government employees	BMI (kg m^{-2}); change in BMI (difference from baseline)/measured weight and height	Self-reported satiation eating (ate to satiety, ate moderately)
Utter *et al.* (2007a) (160)	Both genders/3,042/5–14 years/New Zealand	Cross-sectional/69.3%	Schools	BMI (kg m^{-2})/measured weight and height	Breakfast at home (usually, sometimes, no)
Vagstrand *et al.* (2007) (161)	Both genders/474/16–17 years/Sweden	Cross-sectional/98.5%	Schools	Percentage of body fat (densitometry)/measured weight and height	Breakfast frequency (never, one to four, five to six times per week, daily); fast food intake (yes, no)
van der Heijden *et al.* (2007) (162)	Male/20,064/36–71 years/United States of America	Cohort/10 years/retention rate not reported	Health professionals	Weight change (difference in kg from baseline)/self-reported weight and height	Breakfast consumption (yes, no); daily eating frequency (3, 4, ≥5 eating occasions/d)
Vanelli *et al.* (2005) (163)	Both genders/1,202/6–14 years/Italy	Cross-sectional/response rate not reported	Children admitted to a summer sport school	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Skipping breakfast (<3, ≥3 d/week)

Table 1 *Continued*

Authors (year)	Population aspects: gender/N/age/country	Study design/follow-up duration/ retention rate or response rate	Setting	Dependent variables (definition)/measurement	Independent variables (categories)
Veltsista *et al.* (2010) (164)	Both genders/9,310/16–18 years/Finland, Greece	Cross-sectional/Greek survey: 73.8%; Finnish survey: 77.4%	Population based	Overweight and obesity (BMI cut-offs by IOTF growth charts)/self-reported weight and height	Daily breakfast (yes, no)
Veugelers and Fitzgerald (2005) (165)	Both genders/4,298/10–11 years/Canada	Cross-sectional/51.1%	Schools	Overweight and obesity (BMI cut-offs by IOTF growth charts)/measured weight and height	Eating breakfast (usually eats, does not eat); eating lunch (bring from home, eat at home, buy at school, does not eat); eating at fast food restaurant (<1, 1–2, ≥3 times/week)
Videon and Manning (2003) (166)	Both genders/18,177/mean age: 15.9 years/United States of America	Cross-sectional/79%	High schools	Overweight body perception (yes, no)/self-reported body weight perception	Skipping breakfast (yes, no)
Vik *et al.* (2010) (167)	Both genders/2,870/mean age: 15.5 years/Norway	Cross-sectional/85%	Schools	Overweight (BMI cut-offs by IOTF growth charts)/self-reported weight and height	Number of meals (≤1, 2, 3, 4 meals/d); unhealthy snack (times per week)
Wahlqvist *et al.* (1999) (168)	Both genders/293/≥70 years/Greece, Australia	Cross-sectional/84–89%	General population (from electoral rolls in Greece and telephone directory in Australia)	BMI (kg m^{-2}); percentage of body fat (by Deurenberg equation)/measured weight and height	Episodes of eating (average daily number of episodes)
Wansink and Payne (2008) (169)	Both genders/213/mean age: 35.3–43.4 years/United States of America	Cross-sectional/response rate not reported	Clients of Chinese buffet restaurants	BMI (kg m^{-2})/visual estimates of weight and height by trained observers	Plate size (as a proxy of portion size because people generally 'clean their plate') (large, small)
Wolfe *et al.* (1994) (170)	Both genders/1,797/6–12 years/United States of America	Cross-sectional/51%	Schools	Overweight (BMI cut-offs by NHANES I and II growth charts)/measured weight and height	Skipping breakfast (yes, no)
Woo *et al.* (2008) (171)	Both genders/732/25–74 years/China	Cohort/5–9 years/72.4%	Population based	Overweight (BMI ≥23 kg m^{-2})/measured weight and height	Variety of snack intake (percent difference from baseline)

BMI, body mass index; CDC, Centers of Disease Control and Prevention; FFQ, frequency food questionnaire; HDL, high-density lipoprotein; IOTF, International Obesity Task Force; NHANES, National Health And Nutrition Examination Survey; SD, standard deviation; WC, waist circumference; WHO, World Health Organization.

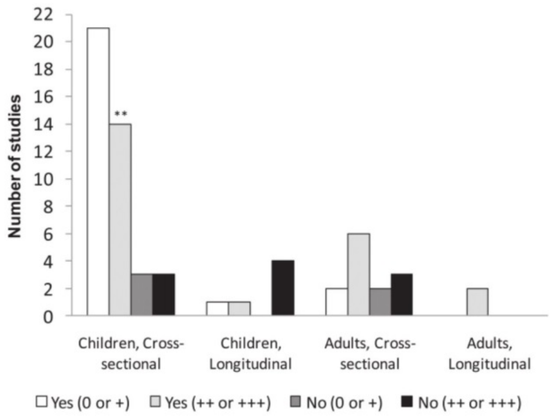

Figure 2 Association between skipping breakfast and excess weight, by study design and population. Number of studies with a significant association (yes) of lack of it (no), and degree of adjustment for potential confounders*. *(0) crude analysis; (+) adjusted for age, gender and a socioeconomic indicator; (++) additionally adjusted for physical activity/sedentariness and smoking; (+++) additionally adjusted for energy intake or eating behaviours. **In one study, eating breakfast regularly was associated with higher body mass index.

Skipping breakfast, lunch or dinner

Sixty-three cross-sectional studies analyzed the relation between skipping meals and excess weight; of these, 17 adjusted for sociodemographic variables, physical activity and energy or food intake. Among the 10 longitudinal studies found, six adjusted for these confounders.

In children and/or adolescents, 35 of the 48 cross-sectional studies included found that skipping breakfast was associated with overweight and/or obesity (Fig. 2, Supporting Information Table S2). This was observed even in studies with anthropometric data based on measurements and with good adjustment for confounders (54,57,81,152,165). However, three studies reported inconsistent sex interactions for the association of interest (65,98,164). Moreover, inconsistent results within studies were found in another two articles with good adjustment for confounders; that is, the association of interest changed depending on the definition of the variable 'skipping breakfast' (55,59). Furthermore, the seven long-term longitudinal studies obtained heterogeneous results. In two studies that did not adjust for physical activity (115) or energy intake (123), skipping breakfast was associated with excess weight. In contrast, neither Affenito *et al.* and Barton *et al.* in North American children, nor Neutzling *et al.* in Brazilian adolescents, observed that skipping breakfast predicted BMI (19,29) or obesity (120) after adjusting for numerous confounders. Timlin *et al.*, in an analysis with good adjustment for confounders, also failed to find a prospective association between breakfast frequency and BMI, although this association had been observed in cross-sectional analyses in the same cohort (156). Finally, two studies observed an association only in children with excess weight at baseline; in one of them, girls who had breakfast ≥1 time/week had lower BMI after 10-year follow-up, and in the other study skipping breakfast was associated with lower BMI after 1 year in girls and boys (22,32) (Supporting Information Table S2). It should be noted that the seven longitudinal studies with children were made in the USA (Table 1) (19,22,29,32,115,123,156).

In adults, the cross-sectional relation between skipping meals and excess weight was uncertain (Fig. 2, Supporting Information Table S2). On the one hand, eight studies found an association between skipping breakfast and obesity; of these, six had a good level of adjustment for potential confounders (31,48,85,95,104,109). On the other hand, five studies did not observe this relation; of these, two adjusted for physical activity and energy intake (74,147). In a study in Spain, obesity was associated with skipping breakfast, but not with skipping lunch or dinner (109). Nor was the metabolic syndrome associated with skipping breakfast in South Korea (143). In contrast, the two longitudinal studies in adults showed results in the same direction: that skipping breakfast was associated with a ≥5% increase in BMI after 1-year follow-up (73), and that having breakfast reduced the risk of gaining 5 kg over a 10-year period (162). Adjustment for confounders was good in both studies.

Daily eating frequency

We found 31 cross-sectional and eight longitudinal studies about the relation between eating frequency and excess weight. Adjustment for sociodemographic, physical activity and energy or food intake variables was performed in 10 of the cross-sectional and in three of the longitudinal studies.

In children and adolescents, the 14 cross-sectional studies showed heterogeneous results (Fig. 3, Supporting Information Table S3). However, the five cross-sectional studies with best adjustment for confounders (39,100,157, 158,167) consistently found that eating more times a day was inversely associated with excess weight. Furthermore, in one case-control study (120) and in two prospective studies (68,154), eating at least three times per day predicted lower BMI and less frequency of obesity.

In adults, seven of the nine cross-sectional studies with good confounders control reported an inverse association between meal frequency and obesity (Fig. 3, Supporting Information Table S3). However, Shin *et al.* did not find an association between meal frequency and the metabolic syndrome (143). Furthermore, one study observed that, in young adults and in those over age 60, eating more than six times a day was associated with higher BMI in comparison

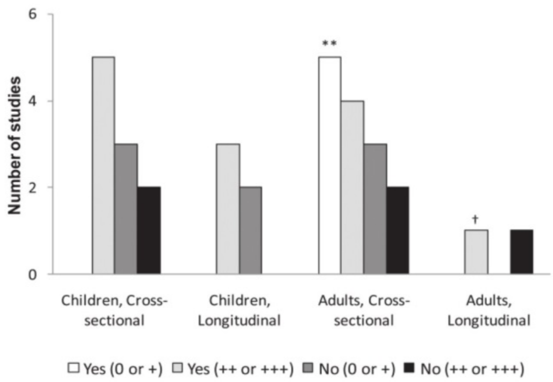

Figure 3 Association between a lower daily eating frequency and excess weight, by study design and population. Number of studies with a significant association (yes) of lack of it (no), and degree of adjustment for potential confounders*. *(0) crude analysis; (+) adjusted for age,, gender and a socioeconomic indicator; (++) additionally adjusted for physical activity/sedentariness and smoking; (+++) additionally adjusted for energy intake or eating behaviours. **In two studies, a higher number of meals were associated with higher frequency of excess weight. †In this study, a higher number of meals were associated with higher frequency of excess weight.

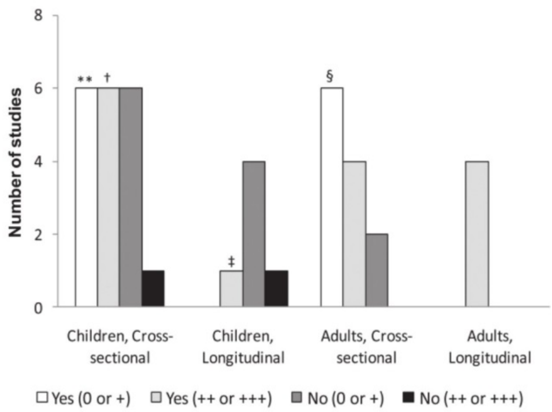

Figure 4 Association between snacking and excess weight, by study design and population. Number of studies with a significant association (yes) of lack of it (no), and degree of adjustment for potential confounders*. *(0) crude analysis; (+) adjusted for age, gender and a socioeconomic indicator; (++) additionally adjusted for physical activity/sedentariness and smoking; (+++) additionally adjusted for energy intake or eating behaviours. **In two studies, higher snacking was associated with lower obesity. †In five studies, higher snacking was associated with lower obesity. ‡In one study, irregular snacking was associated with obesity as compared to regular snacking. §In two studies, higher snacking was associated with lower obesity.

to eating three or fewer times a day (83). Finally, only two prospective studies of this association were identified, both with good confounders control (89,162). In the first, no association was found between meal frequency and weight change in the National Health and Nutrition Examination Survey participants after 8 years of follow-up (89). In the second study, eating four or more times a day, in comparison with eating three times per day, increased the risk of gaining 5 kg over a 10-year period (162) (Fig. 3, Supporting Information Table S3).

Snacking

Thirty-four cross-sectional and 10 longitudinal studies addressed the association between snacking and excess body weight. Six of the cross-sectional and four of the longitudinal studies adjusted for the main confounders.

The definition of snacking varied across studies. Some of them defined snacking as eating between meals (21,30,37, 40,42,49,53,61,66,72,83,86,93,95,108,114,121,137,150), others defined it as consuming small portions of food or packaged food (84,109,139,149) and others as eating specific foods (e.g. fried and salty food, sweets, cakes) (38, 51,63,72,75,80,98,101,113,127,133,134,141,158,167).

In children and adolescents, most of the cross-sectional studies that controlled for confounders showed that lower intake of snacks or lower frequency of snacking was associated with higher BMI or greater frequency of overweight or obesity (42,84,92,149,167) (Fig. 4, Supporting Information Table S4). We identified three prospective studies that controlled for confounders. In the first, no association was found between intake of snack foods (fried and salty food, sweets, cakes) and annual change in BMI-z score in girls or boys (63). In the second study, irregular snacking was associated with a higher risk of obesity than regular snacking; frequency of snacking, however, was not associated with obesity (150). And in the third study, the results changed slightly with the definition of snacking. In particular, frequent snacking between meals was associated with overweight and obesity in each gender, and frequent replacement of meals by snacks was associated with overweight in men (96).

In adults, both the cross-sectional (83,93,109,137) and longitudinal studies (37,49,75,171) with good control for confounders consistently showed that eating between meals, eating snack foods and frequency of snacking episodes were associated with excess weight (Fig. 4, Supporting Information Table S4). Coakley *et al.* observed that eating between meals was associated with increased weight in adults aged 45–64 years, but not in those aged 65 and over (49). Halkjaer *et al.* reported that eating snacks was associated with increased waist circumference over a 5-year period (75).

Irregular meals

Only three articles examined the relationship between irregular meals (variable number of meals per day due to frequent skipping of one or more meals) and BMI or the metabolic syndrome (Supporting Information Table S5). All three had a cross-sectional design and were carried out in adults (21,143,144). The two studies with good control for confounders had inconsistent results. Shin *et al.* reported that a variable number of meals per day were not associated with the metabolic syndrome in comparison with regularly eating three times a day (143); while Sierra-Johnson *et al.* found that eating breakfast, lunch and dinner daily was associated with lower frequency of the metabolic syndrome as compared to eating meals irregularly in persons 60 years of age (144).

Eating away from home

In total, 16 cross-sectional and three longitudinal studies were found on the association between eating away from home and excess weight. Only a few of them controlled for the main confounders.

In children and adolescents, we found six cross-sectional studies; all of them had an insufficient control of confounders, and yielded inconsistent results (Fig. 5, Supporting Information Table S6). In the single longitudinal (case-control) study found, frequent snacking in commercial establishments was more frequent in obese than in normal-weight Brazilian children (126).

In adults, the 10 cross-sectional studies selected were also inconsistent (Fig. 5, Supporting Information Table S6). Moreover, one of them found interaction by sex (38). Specifically, in comparison with eating away from home less than once a week, men who ate out at least once a week had a higher frequency of overweight, whereas the frequency in women was lower (38). Finally, the two longitudinal studies on this association had conflicting results (36,58). In the first study, individuals eating away from home ≥2 times/week had a higher weight gain and a higher risk of overweight or obesity over a 4.4-year follow-up (36). In contrast, in the second study increased consumption of restaurant food was unrelated to BMI change after a 3-year follow-up (58).

Fast food intake

Eighteen cross-sectional studies analyzed the relation between fast food intake and excess weight; of these, only two adjusted for sociodemographic variables, physical activity and energy or food intake. Among the eight longitudinal studies found, five adjusted for these confounders.

Two definitions were used for fast food consumption. Some studies examined the number of times subjects ate in fast food restaurants (41,47,58,69,70,88,123,132,165). Others considered the frequency of eating fast food (e.g. French fries, other fried foods, hot dogs, sandwiches, pizza, etc.) outside the home (not necessarily in a restaurant) (38,151), or regardless of where the food was eaten (at home, at work, in a restaurant) (35,36,40,43,45,59,67,87,101,113,135,139,140,142,161).

Supporting Information Table S7 presents the results of the 26 articles on fast food intake and excess weight. In children and adolescents, the 10 cross-sectional studies conducted showed inconsistent results (Fig. 6). In the only study that adjusted for sociodemographic variables and physical activity, the frequency of fast food consumption was not associated with overfat status (% body fat >25% in boys and >30% in girls) (59). On the other hand, the

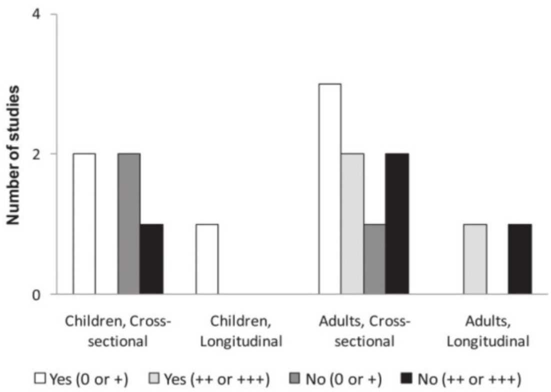

Figure 5 Association between eating away from home and eating frequency and excess weight, by study design and population. Number of studies with a significant association (yes) of lack of it (no), and degree of adjustment for potential confounders*. *(0) crude analysis; (+) adjusted for age, gender and a socioeconomic indicator; (++) additionally adjusted for physical activity/sedentariness and smoking; (+++) additionally adjusted for energy intake or eating behaviours.

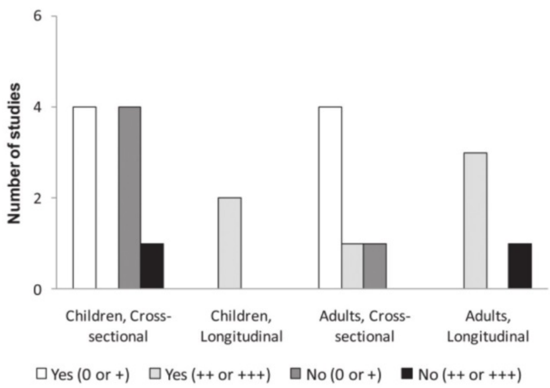

Figure 6 Association between consumption of fast food and excess weight, by study design and population. Number of studies with a significant association (yes) of lack of it (no), and degree of adjustment for potential confounders*. *(0) crude analysis; (+) adjusted for age, gender and a socioeconomic indicator; (++) additionally adjusted for physical activity/sedentariness and smoking; (+++) additionally adjusted for energy intake or eating behaviours.

results of the two longitudinal studies were consistent in showing that consumption of fast food at baseline, or increasing fast food consumption over time (151), was associated with increased BMI (123,151). Confounding was well controlled in both studies (Fig. 6).

In adults, consumption of fast food was associated with excess weight in seven of the eight cross-sectional studies found, although in two of them the association varied by gender (38,67). The association was maintained even in the study of Schroder *et al.* (140), which adjusted for sociodemographic variables, physical activity and energy intake excluding that derived from fast food. Of the six longitudinal studies, four reported that greater frequency of fast food consumption was prospectively associated with weight gain (35,69,132) and with increased BMI (58) (Fig. 6, Supporting Information Table S7).

Takeaway food consumption

In the single study conducted in children, eating takeaway food was not associated with change in BMI after a 10-year prospective follow-up of a small sample ($n = 101$) of North American girls (153) (Supporting Information Table S8). In adults, only three cross-sectional studies were identified, which had inconsistent results. McCrory *et al.* observed that greater frequency of consumption of takeaway food was associated with higher percentage of body fat, in an analysis that was adjusted only for sociodemographic variables (112). Simmons *et al.* did not find an association between consumption of takeaway food and general or abdominal obesity in an analysis with good adjustment for potential confounders (145). Finally, Smith *et al.* reported that consumption of takeaway food was associated with a higher prevalence of overweight in women, and with abdominal obesity in both genders (146) (Supporting Information Table S8).

Food portion size

Only 10 cross-sectional studies were identified (Supporting Information Table S9), and one of them adjusted for physical activity and food intake. In children, three of the six studies included did not find an association between portion size of specific foods (French fries, meats, vegetables, potato chips, biscuits, liquid dairy products and cakes, among others) and excess weight (50,103,111). In contrast, Sun *et al.* observed a greater frequency of overweight in girls and boys with larger eating volume (149). Huang *et al.* also found an association of meal and snack portion sizes with BMI in boys, but not in girls (84).

In adults, only the study of Berg *et al.* had good control of confounders; this study reported higher frequency of obesity in persons who consumed larger portion sizes at the main meals (31). Likewise, Wansink and Payne observed that clients of Chinese all-you-can-eat buffets who ate on larger plates had higher BMI, as subjectively estimated by trained observers, than those with lower BMI (169). On the other hand, Kent and Worsley concluded that adults who consumed larger portions at breakfast had lower BMI than those who ate smaller portions (94).

Eating until full

Two cross-sectional studies and one cohort study examined the relation between eating until full and excess weight in adults in Japan (Supporting Information Table S10). Only one cross-sectional study adjusted for energy intake. In the cross-sectional studies, eating until full was associated with overweight in both men and women (110,124). In the cohort study, Toyoshima *et al.* reported that eating until full is associated with increased BMI after 5-year follow-up, but only in persons with a high level of self-reported stress (159).

Eating quickly

Supporting Information Table S11 presents the eight studies on eating speed and excess weight. Four studies in children and adolescents were selected, one with a cross-sectional design (149), one case-control (78) and two experimental studies (28,99). An additional four studies were identified in adults, all of them conducted in eastern Asia (110,124,129,143). All the mentioned studies found that eating more quickly is associated with excess weight, independently of physical activity or energy intake. One of the experiments found that overweight children ate more quickly than those with normal weight, but this occurred only when the mother was present in the laboratory (99).

Discussion

Although diet is obviously linked to obesity, this systematic and comprehensive review of the literature has shown that evidence on the relation between selected eating behaviours and obesity is still scarce or inconsistent in both children and adults. Given that the definitions of eating behaviours varied across the reviewed articles, it suggests that a more systematic approach is needed for capturing the effects of behavioural phenomena on weight control.

Numerous cross-sectional studies in children have observed that skipping breakfast is associated with higher body weight and obesity. In fact, a pilot study with overweight teen girls has found that eating breakfast, specially one rich in protein, leads to reduced activation in brain regions that support reward-driven eating behaviour (172). This suggests a possible mechanism to explain how eating breakfast and its composition could contribute in the prevention of weight gain in adolescents. However, it may also be that skipping breakfast is a reflection of dieting in overweight persons who try to control their weight. For instance, in two studies lower frequency of eating breakfast was associated with excess body weight in cross-sectional analyses at baseline and end of follow-up, but not in the longitudinal analyses (32,156). Furthermore, skipping breakfast may merely be a general indicator of lifestyle; there is evidence that skipping breakfast is associated with a less healthy diet and less physical activity (11,15). However, most studies do not control for these variables. A previous review based on 16 studies suggested that eating breakfast was associated with a reduced frequency of overweight or obesity and with a lower BMI among children and adolescents in Europe. However, almost all of reviewed studies were cross-sectional, so that causality cannot be inferred from their findings (15).

In adults, two prospective studies with good control of potential confounders found that eating breakfast could protect against weight gain (73,162). This finding has some biological plausibility because skipping breakfast may lead to increased ghrelin secretion and a greater feeling of hunger, over-eating during the day and impaired postprandial insulin and glucose responses (12). Moreover, Pereira *et al.* have recently shown that breakfast frequency and quality may be related in causal ways to appetite control and blood sugar control in children and adults. Thus, their results support the hypothesis that breakfast and its composition may have causal implications for the risk of obesity and type 2 diabetes (173). However, it is difficult to distinguish the effect of eating breakfast from the effect of what the breakfast contains. In fact, an inverse association has been reported between eating cereal for breakfast and body weight (174). Moreover, in one of the studies some dietary factors, such as nutrient and fibre intake and number of eating occasions, explained part of the inverse association between breakfast and weight gain (162). Finally, the results of the two studies may not be completely applicable to the general population, because they were conducted only in men – in university students in one case (73) and in health professionals in the other (162).

Greater meal frequency has classically been associated with a lower frequency of obesity. In a recent review, Koletzko and Toschke reported an association between skipping meals and increased risk of obesity in children, and suggested that it is prudent to promote a regular pattern of five meals per day among children and their families (16). However, their results were based on only five studies; three of them found a significant reduction of obesity risk with increasing number of meals, while the other two studies found a non-significant trend in the same direction (16). In the present review of 38 studies, we have not found sufficient evidence for the association between meal frequency and excess body weight at any age. This may be due to several reasons. On the one hand, the definition of meals is heterogeneous because it includes both the main meals (e.g. skipping breakfast reduces the number of meals), and additional ones (in some studies, not snacking could also reduce the number of meals) (98). There is also a predominance of cross-sectional studies (with limited capacity to show causality), with little control of confounders, when it is known that low-meal frequency is associated with unhealthy lifestyles, especially in children (16). Moreover, a recent review of clinical trials (mostly of small size and duration) of weight-loss and weight-maintenance interventions concluded that there is no association between eating frequency and body weight (175). Notwithstanding this, our review identified three good-quality prospective studies in children suggesting that three or more regular meals per day may be useful in preventing excess weight gain (68,120,154). This hypothesis should be tested in appropriately designed trials. It is also important to clarify the impact on weight gain of factors associated with eating frequency, such as hunger and appetite control. Leidy and Campbell have reviewed the controlled-feeding studies that primarily targeted the appetitive, hormonal and food intake responses potentially altered with eating frequency (176). They concluded that the increased eating frequency (>3 eating occasions/d) has minimal, if any, impact on appetite control and food intake, whereas reduced eating frequency (<3 eating occasions/d) negatively affects appetite control (176).

We also failed to find clear evidence of an association between snacking and excess weight, especially in children and adolescents. This may be due to the use of different definitions of snacking. Furthermore, one of the most common definitions (i.e. any intake between traditional meals) lacks a physiological basis (177). The use of a cross-sectional design may also explain why various studies have found that lower frequency of snacking was associated with higher body weight (51,84,92,149,167), contrary to what would be expected. In contrast, various longitudinal studies in adults with good control of confounders have consistently observed a higher frequency of obesity in those who snack several times a day. One explanation for this association may be that the saturated fats and total energy provided by snacks are not compensated for by reduced intake at the main meals (177).

Eating outside the home, consuming fast food and eating takeaway food tend to be associated. Furthermore, fast food is highly palatable, rich in sugar, saturated fats and trans fats, usually eaten in large portions and accompanied by sugary drinks, and can lead to excessive energy intake (14). There is also experimental evidence that children, particularly those who are obese, generally over-eat fast food and do not compensate for the additional energy provided by this meal (178). Other experimental studies have shown that subjects who are given large portions at meals have higher energy intake (179,180). However, as already pointed out in a previous review (14), only a few longitudinal studies in children (123,151) and adults (35,58,132) have shown that fast food is associated with excess weight. One reason is that, compared with non-obese persons, the obese underreport total energy intake and, specifically, fried food (181), which is a characteristic component of fast food; this tend to bias the observed associations towards the null. An additional problem is that some study behaviours are measured in the laboratory better than in free-living populations. One case is meal size. There is evidence in laboratory settings that, as compared with individuals whose weight is stable, those gaining weight ingest more energy and that it results, in part, from larger meal sizes (182). However, in epidemiological studies meal size is usually estimated from the size of the dish where food is served, the frequency of consumption of supersized portions or a picture representing the average size of the food. It is also possible that fast food may simply be a marker of low socioeconomic level, of low quality diet and of an unhealthy lifestyle (4,69,151). One problem with the literature in this field is the failure to systematically use a clear theoretical framework to establish whether the relevant eating behaviour for obesity is the amount or frequency of fast food consumption, its composition, where it is prepared and consumed or other associated lifestyle (e.g. watching television while eating). This theoretical framework would also suggest the appropriate adjustment variables. Thus, while it is possible to conceive that a poor diet associated with fast food consumption is a confounding factor that should be controlled, it can also be understood as a mediator of the study association for which adjustment should not be made.

The influence of some psychological and environmental factors related to the studied eating behaviours also needs to be considered. Psychological research has shown that some eating behaviour traits (cognitive dietary restraint, disinhibition and susceptibility to hunger) are associated with excess body weight (183,184) or weight gain (185). Thus, it is reasonable to expect that these behaviour traits may act as determinants of several eating behaviours (e.g. skipping breakfast, fast food consumption, eating until full) or as effect modifiers of the relation between the eating behaviours and excess weight. In contrast, other studies have suggested that eating could be an automatic behaviour over which the environment has more control than do individuals, suggesting that the focus of obesity prevention should be less on nutrition education and more on shaping the food environment (186). However, the increased environmental access of fast food establishments, for example, has been related to higher BMI in only seven of 15 studies recently reviewed (187). Thus, further research is needed to understand the contribution of these eating behaviour traits and external environmental factors to the relation between the eating behaviours covered in this review and excess body weight.

In summary, there is short-term ecological and experimental evidence of the obesogenic role of fast food and other associated variables (eating away from home, takeaway food and eating large food portions). There is also some evidence from large longitudinal studies, but as yet this is limited. Moreover, only one longitudinal study has assessed the medium- and long-term obesogenic effect of takeaway food (which did not manage to show such an association) (153), and no longitudinal study is available on the effect of eating large food portions.

Finally, no longitudinal studies were found regarding the influence on body weight of irregular meals, eating until full (in children) and eating quickly (in adults). Overall, the small evidence on these three eating behaviours does not allow to establish their effect on obesity, even though this relation is biologically plausible (e.g. eating quickly or until full may lead to increased energy intake).

We conclude that more research is needed to formulate sound recommendations on eating behaviours for obesity prevention in children and adults. Our review suggests several directions for improving future studies in this field. First, standardized definitions of eating behaviours should be used, and these behaviours should be measured with rigorously validated questionnaires. This limitation of the existing literature can explain, in part, the inconsistencies of the results reported. This is especially applicable to consumption of snacks, fast food, takeaway food and eating away from home, because these behaviours are interrelated; in this review, it was particularly challenging to distinguish which specific eating behaviour was being measured in some studies. Moreover, the development of questionnaires for certain behaviours (e.g. eating quickly, eating until full) may be challenging because eating is a relatively automatic behaviour (186) and self-reported measures may have limited value to accurately estimate real behaviour. Second, unlike the studies to date, most new research should consider various eating behaviours simultaneously within a suitable theoretical framework. Third, the analyses should adjust for socioeconomic level, lifestyles (especially physical activity and sedentarism) and, in some cases, for overall dietary patterns derived from cluster or factor analysis. Fourth, priority should be given to long-term longitudinal studies (with repeated measures of the exposure and of body weight) and short-term clinical trials (4). Finally, transcultural variability in eating behaviours should be taken into account. For example, in the USA fried foods are usually associated with fast food, whereas in southern Europe, food fried in olive oil is a basic component of the Mediterranean diet. Or in the USA, eating away from home is usually associated with fast food. This is not the case in Mediterranean countries, where most restaurants serve traditional food. Also, skipping breakfast can have different implications depending on the country. For example, in Spain a regular meal is frequently eaten at mid-morning (10–11 a.m.), before lunch (2 p.m.). The mid-morning meal can compensate for a light breakfast and even for skipping breakfast. In the USA and in countries of central and northern Europe, skipping breakfast would probably be compensated for with snacks.

Conflict of Interest Statement

The authors have indicated no conflicts of interest.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

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Table S3. Association between daily eating frequency and excess weight, by study design and population.
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6. ARTÍCULO 2: The Diet of Diabetic Patients in Spain 2008-2010: Accordance with the Main Dietary Recommendations A Cross-Sectional Study

La dieta de los pacientes diabéticos en España en 2008-2010: Acuerdo con las principales recomendaciones dietéticas — Un estudio transversal.

(PLoS ONE 2012; e39454)

Antecedentes: No existen estudios previos que hayan evaluado la dieta de pacientes diabéticos en la población general de un país completo en Europa. Este estudio evalúa el acuerdo de la dieta de los diabéticos adultos en España con las principales recomendaciones nutricionales de la European Association for the Study of Diabetes (EASD), American Diabetes Association (ADA), y la dieta Mediterránea (DM).

Métodos: Estudio transversal realizado en 2008-2010 en 12.948 personas representativas de la población española no institucionalizada de 18 años y más. Se definió diabetes como glucemia en ayunas ≥126 mg/dl o recibir tratamiento antidiabético. El consumo habitual de alimento se valoró con una historia dietética computarizada. El acuerdo con EASD se definió como ≥6 puntos de un score de 12 objetivos nutricionales, el acuerdo con ADA como ≥3 puntos de un score de 6 objetivos, y el acuerdo con DM como ≥7 puntos del score “Mediterranean Diet Adherence Screener”.

Resultados: En los 609 diabéticos diagnosticados, la dieta era rica en grasa saturada (11.2% de energía total); sin embargo la ingesta de grasas trans fue relativamente baja (1.1%) y la de grasa moninsaturada alta (16.1%). La ingesta de hidratos de carbono era relativamente baja (41.1%), pero la de azúcares era alta (16.9%). También fue elevada la ingesta de colesterol (322 mg/día) y sodio (3.1 g/día), mientras la ingesta de fibra fue insuficiente (23.8 g/día). En los diabéticos diagnosticados, el 47.8% (IC 95% 44.0-53.5) tuvo acuerdo con EASD, el 46.3% (IC 95% 41.7-51.0) tuvo acuerdo con ADA, y el 57.4% (IC 95% 52.6-62.3) tuvo acuerdo con DM. No hubo diferencias estadísticamente significativas entre los diabéticos diagnosticados y los no diagnosticados en la frecuencia de acuerdo EASD, ADA o con la DM.

Conclusión: Sólo alrededor de la mitad de los diabéticos españoles tiene una dieta acorde con las principales recomendaciones dietéticas. Además, la falta de diferencias en la dieta entre los diabéticos diagnosticados y los no diagnosticados pone de manifiesto deficiencias del sistema sanitario en el manejo de la diabetes.

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The Diet of Diabetic Patients in Spain in 2008–2010: Accordance with the Main Dietary Recommendations—A Cross-Sectional Study

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Abstract

Background: No previous study has assessed the diet of the diabetic patients in the general population of an entire country in Europe. This study evaluates accordance of the diet of diabetic adults in Spain with nutritional recommendations of the European Association for the Study of Diabetes (EASD), American Diabetes Association (ADA), and the Mediterranean diet (MD).

Methods and Findings: Cross-sectional study conducted in 2008–2010 among 12,948 persons representative of the population aged ≥18 years in Spain. Usual food consumption was assessed with a dietary history. EASD accordance was defined as ≥6 points on a score of 12 nutritional goals, ADA accordance as ≥3 points on a score of 6 goals, and MD accordance as ≥7 points on the Mediterranean Diet Adherence Screener. In the 609 diagnosed diabetic individuals, the diet was rich in saturated fat (11.2% of total energy), but trans fat intake was relatively low (1.1% energy) and monounsaturated fat intake was high (16.1% energy). Carbohydrate intake was relatively low (41.1% energy), but sugar intake was high (16.9% energy). Intake of cholesterol (322 mg/day) and sodium (3.1 g/day) was also high, while fiber intake was insufficient (23.8 g/day). EASD accordance was observed in 48.7% diabetic patients, ADA accordance in 46.3%, and MD accordance in 57.4%. The frequency of EASD, ADA and MD accordance was not statistically different between diagnosed and undiagnosed diabetic individuals.

Conclusions: Only about half of diabetic patients in Spain have a diet that is consistent with the major dietary recommendations. The lack of dietary differences between diagnosed and undiagnosed diabetic individuals reflects deficiencies in diabetes management.

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Introduction

Nutritional therapy is an integral component in the prevention and management of diabetes mellitus [1]. In clinical trials, nutritional therapy has shown sustained improvements in glycated hemoglobin (HbA1c) [1]. Moreover, combining this type of therapy with other lifestyle interventions (e.g., physical activity, smoking cessation), can further improve clinical and metabolic outcomes [1]. The Mediterranean diet (MD), in particular, has been shown to reduce the risk of type 2 diabetes [2]. The MD also facilitates weight loss [3], glycemic control, and control of the main cardiovascular risk factors associated with diabetes [4].

Accordingly, various scientific societies have developed recommendations for the nutritional management of diabetes [5–8]. Surprisingly, however, only a few population-based studies have examined the diet of persons with diabetes. Two analyses from the National Health and Nutrition Examination Surveys (NHANES) conducted from 1999 to 2002 showed important deficiencies (e.g., excessive intake of saturated fat and low fiber intake) in the diet of a representative sample of adults with diabetes in the US [9,10]. Low compliance with nutritional recommendations for persons with diabetes has been reported in Europe, but most of these studies were clinic-based [11–14] or in participants in cohort studies [15,16] who are not representative of diabetic persons in the general population. Furthermore, some of these studies recruited only insulin-dependent diabetic patients [11], or elderly men [15]. In addition, two population-based European studies included only local samples [17,18], and one of them included only elderly persons [18]. Finally, the studies were made at least 10 years ago, so that they may no longer represent the current diet of diabetic subjects.

This article examines the diet of a representative sample of persons with diabetes in Spain in 2008–2010 and assesses the level of accordance with the main dietary recommendations.

Methods

Study Design and Participants

The data were taken from the Study on Nutrition and Cardiovascular Risk in Spain (ENRICA), whose methods have been reported elsewhere [19]. This is a cross-sectional study conducted between June 2008 and October 2010 in 12,948 individuals representative of the non-institutionalized Spanish population aged 18 years and over. The sample was first stratified by province and size of municipality of residence. Clusters were then randomly selected in two stages: municipalities and census sections. Finally, within each section households were randomly selected using the directory of fixed telephone lines as the sampling frame. Subjects in the households were selected proportionally to the distribution of the population of Spain by age and sex.

The information was collected in three stages: first, by telephone interview on lifestyles and diagnosed morbidity; second, by household visit to obtain samples of blood and urine samples; and third, by another household visit for anthropometry, measurement of blood pressure and collection of a computerized dietary history. The response rate in the study was 51%.

Ethics

The study participants provided written informed consent. The ENRICA protocol was approved by the Clinical Research Ethics Committees of the "La Paz" Hospital in Madrid and the "Clinic" Hospital in Barcelona.

Study Variables

Diabetes mellitus. Twelve-hour fasting blood glucose was measured using the oxidase glucose technique (ADVIS 2400 Chemistry System analyzer, Siemens). Diabetes mellitus was defined as glucose ≥126 mg/dl [1] or use of antidiabetic medication. Since nutritional therapy is done only in persons with diagnosed diabetes, the data analyses included only diabetic subjects who responded affirmatively to the question: "Have you ever been told by the doctor that you had diabetes or elevated blood sugar?".

Glycemic control was assessed by the level of HbA1c, measured by high-performance liquid chromatography (Adams A1c HA-8160, Arkray). Good glycemic control was defined as HbA1c <7% [1].

Diet. Diet in the previous year was collected using a computerized dietary history developed from the one used in the EPIC-Spain study [20–21]. Nutrient intake was calculated using Spanish food composition tables [19].

The quality of the diet of diabetic subjects was evaluated according to the level of accordance with the nutritional recommendations of the European Association for the Study of Diabetes (EASD) [5] and the American Diabetes Association (ADA) [6]. Based on the 12 main nutritional recommendations of the EASD (figure 1), a score was developed that awarded 1 point if the recommendation was met and 0 if it was not met. The final score was calculated as the sum of points for each recommendation (range 0–12); as with similar scores [22], moderate accordance was considered as a score equal to or higher than the intermediate value (≥6 points). An analogous score was constructed to assess accordance with the ADA recommendations. Although the diet recommended by the ADA is consistent with the EASD diet, several ADA recommendations are not formulated quantitatively so that it is not possible to score adherence to them. Consequently, only six recommendations (figure 1) were considered: the ADA score ranged from 0 to 6, and moderate accordance was defined as ≥3 points.

Accordance with the MD was evaluated with the Mediterranean Diet Adherence Screener (MEDAS) [23] developed by the PREDIMED study, a clinical trial of the effect of the traditional MD on the primary prevention of cardiovascular disease [24]. The MEDAS consists of 12 items with goals for food consumption and 2 items with goals for food intake habits characteristic of the Spanish MD. We slightly modified the MEDAS because, in contrast to the original questionnaire, goal achievement for vegetable consumption did not require that at least one of the two daily servings had to be consumed as raw vegetables or a salad. A score of 1 point was assigned for reaching each goal. The MEDAS score ranges from 0 to 14, with a higher score indicating better accordance with the MD. A score of ≥7 was considered as moderate accordance with the MD.

Other variables. Study participants reported sociodemographic variables (sex, age, educational level) and lifestyles such as smoking and time spent watching television. Leisure time physical activity was obtained with the EPIC-Spain questionnaire [25], and was expressed in METs-h/week.

Weight, height and waist circumference were measured under standardized conditions [26]. Body mass index (BMI) was calculated as weight in kg divided by height squared in meters, and abdominal obesity was defined as waist circumference >102 cm in men and >88 in women.

Blood pressure was measured with standardized procedures using validated automatic devices (Omron model M6) and three cuff sizes according to arm circumference [27]. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg or drug treatment for hypertension. For the analysis we selected subjects who had been diagnosed with hypertension, that is, hypertensive individuals who responded affirmatively to the question "Have you ever been told by the doctor that you had hypertension, also called high blood pressure?".

Statistical Analysis

Of the 12,948 study participants, we excluded the 221 who lacked data on fasting blood glucose. Thus, the analysis was performed with 12,727 individuals, from which we selected the 876 with fasting blood glucose ≥126 mg/dl or who were using antidiabetic medication. From these, we selected the 696 who were aware of their diabetes and, from these, the 635 whose energy intake was within a valid range (for men: >800 to <5000 kcal/day; for women: >500 a <4000 kcal/day) [28,29]. Finally, we selected those who had complete information for the remaining study variables, resulting in 609 individuals included in the final analytical sample.

The statistical analysis was primarily descriptive: calculation of the percentage and its 95% confidence interval (CI) of persons with diagnosed diabetes whose diet accorded with the recommendations of the EASD, ADA and DM. To summarize the association between the sociodemographic, lifestyle and clinical variables and accordance with the EASD and MD recommendations, we calculated odds ratios (OR) and their 95% CI from logistic models adjusted for sex and age (18–44, 45–64, ≥65 years). To assess the dose-response relation with age, physical activity, time spent watching television and BMI, we modeled the median of each tertile and estimated p-values for linear trend. For educational level, p for trend was based on scores (1, 2, 3) assigned

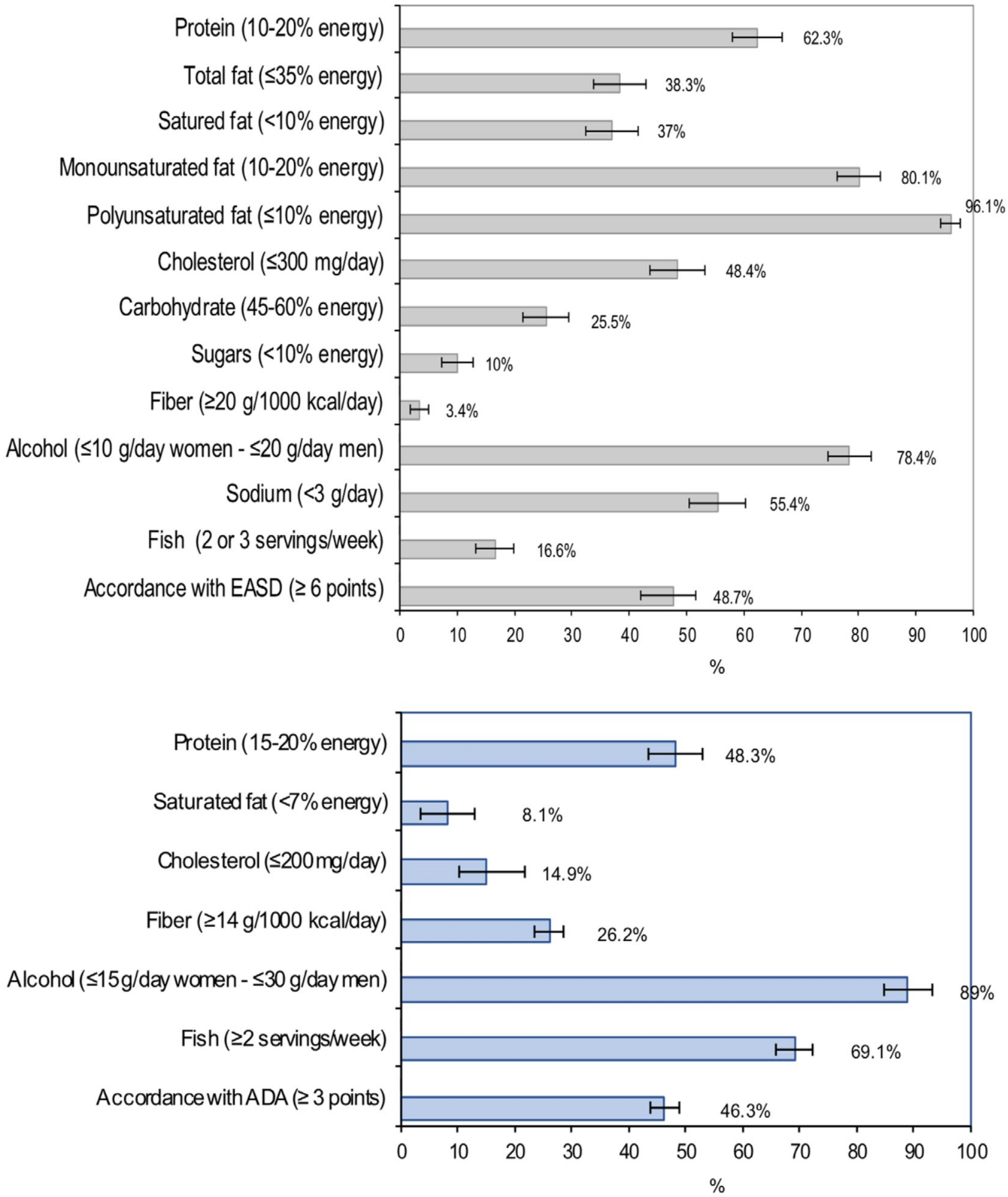

Figure 1. Accordance with nutrient recommendations of EASD and ADA. Percentage of diagnosed diabetic subjects who achieved each nutrient recommendation of the EASD (figure a) and ADA (figure b) and accordance with EASD (figure a) and ADA (figure b). Bars represent 95% confidence intervals.
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to primary or less, secondary and university education, respectively.

Statistical significance was set as two-sided $p<0.05$. To take account of the complex sampling design, individual observations were weighted to reconstruct the Spanish population, and the variances were corrected to obtain appropriate 95% CI for the main results. The analyses were performed with the survey procedures of Stata v.11 [30].

Results

Table 1 shows the main characteristics of subjects diagnosed with diabetes in the ENRICA study. Of note is that over 70% had abdominal obesity and almost 60% suffered hypertension. Two-thirds were being treated only with oral antidiabetic medications. Their diet was rich in saturated fats; however, trans fat intake was relatively low and monounsaturated fat intake was high. Carbohydrate intake was relatively low, but sugar intake was high. Cholesterol and sodium intake were both also high. Finally, only 69.2% of those with diabetes had good glucose control.

Figure 1 shows the percentage of diabetic subjects who followed the EASD and ADA nutritional recommendations. A large percentage met the recommendations for intake of unsaturated fats, alcohol and proteins, but less than 10% reached the goals for sugar and fiber intake, and only 25% met those for carbohydrates. Of note is that although mean fish consumption was high (4 portions/week), the EASD recommends consumption of just 2 or 3 portions/week, therefore only 16.6% had the recommended amount. The mean EASD score was 5.51 (95% CI 5.35–5.69), and accordance with the EASD recommendations (score ≥6 points) was reached in 48.7% of individuals (95% CI 44.0–53.5%).

With regard to the ADA recommendations, only 8% and 15% of individuals, respectively, reached the goals for intake of saturated fats and cholesterol, which are more stringent than those in the EASD recommendations. In contrast, over 25% reached the goal for fiber intake (less stringent than the EASD), and almost 70% reached the goal for fish consumption (≥2 portions/week). The mean ADA score was 2.55 (95% CI 2.45–2.66), and accordance with the ADA recommendations (score ≥3 points) was reached in 46.3% (95% CI 41.7–51.0%) of diabetic subjects. Because compliance with the goals for fiber and fish intake are higher for the ADA than for the EASD recommendations, calculation of the EASD score using the ADA recommendations for fiber and fish consumption increased the percentage of subjects with moderate accordance with EASD, from 48% to 62%.

In the analyses adjusted for age and sex, accordance with EASD recommendations increased with age, and was higher in women and in individuals with hypertension (table 2).

Figure 2 presents the percentage of diabetic individuals who followed the MD as assessed with MEDAS. Over 80% reached the goals on use of olive oil as the main cooking oil, consumption of red meat, animal fats, carbonated or sugar-sweetened beverages, and foods prepared with "sofritos" (a commonly used Spanish sauce made with tomato and onion, leek and/or garlic sautéed in olive oil). Furthermore, almost 60% of diabetic subjects consumed ≥3 portions/week of fish, and a similar proportion consumed commercial desserts <2 times/week. In contrast, less than 20% reached the goals for consumption of vegetables, pulses, and nuts. The mean MEDAS score was 6.83 (95% CI 6.65–7.02), and accordance with the MD (≥7 points) was reached in 57.4% (95% CI 52.6–62.3%) of individuals. After excluding the goal on wine consumption, accordance with the MD rose to 74.9% (95% CI 70.3–79.3%) (score ≥6 points on MEDAS with 13 goals). However, only 0.4% of subjects met all 14 dietary goals of MEDAS.

Moderate accordance with the MD was higher in persons ≥65 years of age, but was lower in women (table 3). However, after eliminating the goal on wine consumption from the MEDAS score, the association with sex disappeared (OR 0.79; 95% CI 0.50–1.27).

Individuals with MD accordance more frequently had good glucose control (HbA1c <7%), both in the analysis adjusted for age and sex and in the one additionally adjusted for various lifestyle and clinical variables (table 4). Moreover, in the linear regression analysis, the higher the MEDAS score, the lower the HbA1c level (fully-adjusted β −0.055%/1-unit increase in MEDAS score; 95% CI −0.11 to −0.004%/1-unit in MEDAS

Table 1. Characteristics of diagnosed diabetic subjects in the ENRICA Study.

	Diagnosed diabetics n = 609
Male sex	59.1%
Age, years	
18–44	7.3%
45–64	36.3%
≥65	56.4%
Educational level	
Primary school or less	56.9%
Secondary school	25.2%
University	18.0%
Smoking	
Never smokers	48.2%
Past smokers	36.9%
Current smokers	14.8%
Physical activity, METs-h/week	23.0 (18.49)
Hours spent watching TV, h/week	18.7 (11.23)
Body mass index, kg/m^2	
<25	13.0%
25–29.9	39.9%
≥30	47.1%
Abdominal obesity	71.4%
Hypertension	57.5%
Diabetes treatment	
Oral	67.6%
Insulin	10.1%
Oral+Insulin	9.6%
Without drug treatment	12.6%
Total energy intake, kcal/day	2,055 (32.22)
Dietary intake,	
Total protein, % of energy	19.2 (3.88)
Total fat, % of energy	36.7 (6.49)
Saturated, % of energy	11.2 (3.14)
Trans	1.1 (0.56)
Monounsaturated, % of energy	16.1(3.73)
Polyunsaturated, % of energy	6.1(1.87)
Cholesterol, mg/day	322.2 (129.26)
Carbohydrate, % of energy	41.1(7.14)
Sugars, % of energy	16.9 (5.77)
Fiber, g/day	23.8 (7.99)
Alcohol, g/day	9.1 (15.58)
Total sodium, g/day	3.1 (1.31)
HbA1c <7%	69.2%

For continuous variables, the mean (standard deviation) is reported.
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Table 2. Variables associated with accordance with the EASD diet.

	Accordance with EASD diet	
	% (95% CI)	Odds ratio (95% CI) [a]
Sex		
Male	41.9 (35.8–47.8)	1.00 (Ref.)
Female	58.8 (51.5–66.1)	1.79 (1.21–2.65)
Age, years		
18–44	29.6 (13.8–45.4)	1.00 (Ref.)
45–64	39.9 (32.2–47.6)	1.64 (0.70–3.82)
≥65	56.9 (50.9–62.9)	2.96 (1.30–6.75)
p for trend		<0.001
Educational level		
Primary school or less	55.1 (48.9–61.2)	1.00 (Ref.)
Secondary school	40.5 (31.2–49.7)	0.75 (0.46–1.23)
University	40.3 (29.8–50.9)	0.76 (0.47–1.27)
p for trend		0.219
Smoking		
Never smokers	43.7 (32.2–55.1)	1.00 (Ref.)
Past smokers	44.4 (36.3–52.4)	0.96 (0.59–1.56)
Current smokers	53.6 (46.9–60.5)	1.01 (0.57–1.78)
Physical activity, METs-h/week		
Tertile 1 (<13.5)	52.1 (43.9–60.4)	1.00 (Ref.)
Tertile 2 (≥13.5 to <26.3)	46.4 (38.4–54.4)	0.86 (0.54–1.40)
Tertile 3 (≥26.3)	47.9 (39.4–56.5)	1.21 (0.74–1.95)
p for trend		0.445
Hours spent watching TV, h/week		
Tertile 1 (<14)	43.9 (34.9–52.8)	1.00 (Ref.)
Tertile 2 (≥14 to <21)	50.9 (41.6–60.2)	1.25 (0.74–2.11)
Tertile 3 (≥21)	50.9 (44.0–57.8)	1.03 (0.65–1.65)
p for trend		0.928
Body mass index, kg/m^2		
<25	51.6 (38.9–64.3)	1.00 (Ref.)
25–29.9	46.5 (38.8–54.3)	0.77 (0.42–1.43)
≥30	49.9 (42.9–56.9)	0.85 (0.45–1.59)
p for trend		0.842
Abdominal obesity		
No	48.8 (40.3–57.4)	1.00 (Ref.)
Yes	48.7 (43.0–54.5)	0.88 (0.57–1.37)
Hypertension		
No	40.4 (33.3–47.6)	1.00 (Ref.)
Yes	54.9 (48.9–60.9)	1.60 (1.09–2.35)
Diabetes treatment		
Oral	50.1 (44.3–55.8)	1.00 (Ref.)
Insulin	48.9 (33.6–64.2)	1.23 (0.64–2.34)
Oral+Insulin	50.6 (35.9–65.3)	1.00 (0.52–1.93)
Without drug treatment	40.3 (26.9–53.6)	0.86 (0.46–1.59)

[a]Odds ratio adjusted for sex and age.
n = 609.
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score). The results for accordance with the EASD and ADA recommendations were in the same direction, but did not reach statistical significance (table 4).

Finally, we compared the diet of the 609 diagnosed diabetic persons with the 180 who were not aware of their diabetes in the ENRICA study. In the analyses adjusted for age and sex, there were no statistically significant differences between these two groups in the frequency of accordance with the recommendations of the EASD (OR 0.95; 95% CI 0.63–1.94), ADA (OR 1.16; 95% CI 0.76–1.76) or MD (OR 0.86; 95% CI 0.56–1.33). Moreover we found no evidence that differences in healthy diet accordance by diagnostic status varied with age (p for interaction >0.20 in all cases).

Discussion

Interpretation of the Key Findings

Our results show that only about half of Spaniards with diabetes have a diet accordant with the recommendations of the EASD, ADA or the MD pattern. Moreover, the absence of dietary differences between diagnosed and undiagnosed individuals with diabetes suggests deficiencies in the health care system in the management of diabetes.

Although there is room for improvement, the diet of persons with diabetes in Spain has some healthy characteristics that would be expected in Mediterranean countries. Specifically, the high intake of mono- and poly-unsaturated fat, which is consistent with the high consumption of olive oil, fish and plant-based foods. Furthermore, although achievement of the goals for consumption of fiber, fruits and vegetables is low (probably because the goals are quite stringent), consumption of these products was fairly substantial. Mean fiber intake was 23.8 g/day, and mean intake of fruits and vegetables was 305 g/day (2.5 servings) and 277 g/day (1.4 servings), respectively.

Thus, the diet of diabetic persons in Spain is consistent with the so-called "evolved Mediterranean diet" (EMD), which is the diet of the Spanish population today [31–33]. The EMD maintains considerable intake of olive oil and plant-based foods and moderate consumption of fish, which are typical of the MD, but has incorporated excessive consumption of foods characteristic of the Western diet in industrialized countries, such as animal products rich in saturated fats and cholesterol, and foods high in sugar, which displace complex carbohydrates. Nonetheless, carbohydrates and monounsaturated fat still represent 57.2% of total energy in diagnosed diabetic persons. Salt consumption in the EMD is also excessive, so that only half of diabetic individuals consume <3 g sodium/day. This is important because more than half of those diagnosed with diabetes have also been diagnosed with hypertension.

Among diabetic subjects, accordance with the main food recommendations increased with age. This is consistent with the results of studies in the general population in Spain, which have found that older adults have higher compliance with nutritional goals and higher adherence to the MD [34,35]. This is likely due to cultural reasons, and to the fact that it is easier for older people to cook and eat at home.

Comparison of our results with those of previous studies is difficult due to methodological differences in the participant's selection (e.g. clinic-based, cohort-based or population-based sampling) and in instruments used to collect dietary data (food frequency questionnaire, 12-hour recall, 7-day records, diet history). Nevertheless, the literature shows that the diet of diabetic subjects is similar to that of the general population in each country [15,17,18] or that of non-diabetic persons in the same cohort [16].

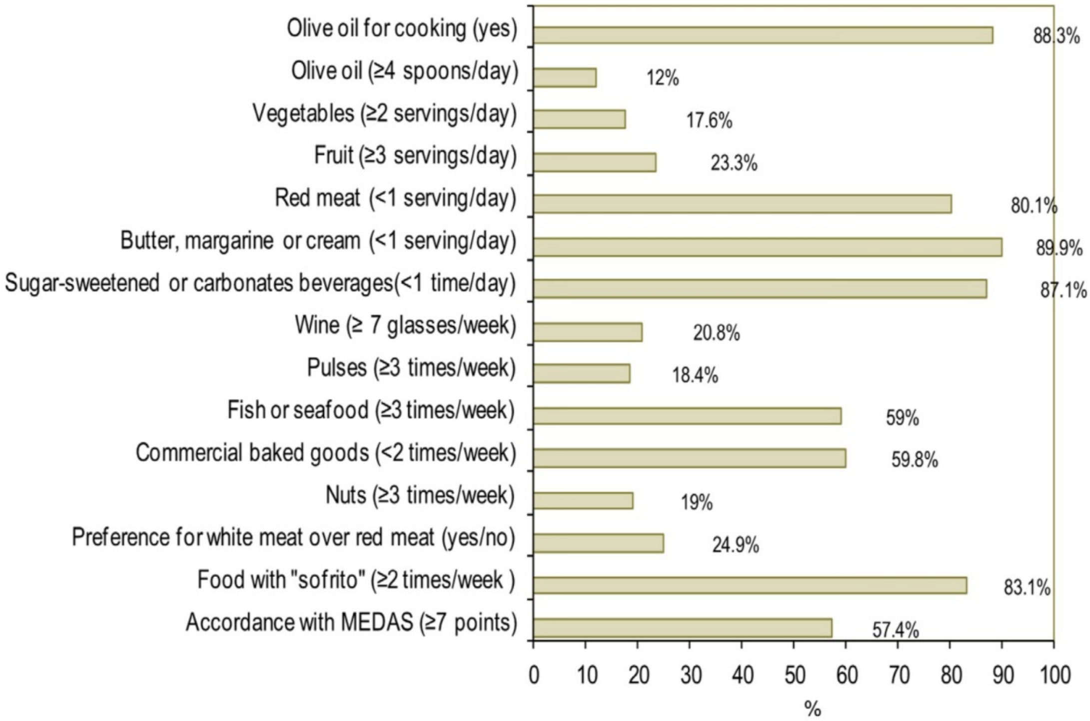

Figure 2. Accordance with the Mediterranean diet. Percentage of diagnosed diabetic subjects who achieved each target of the Mediterranean Diet Adherence Screener (MEDAS) and accordance with the Mediterranean diet. Bars represent 95% confidence intervals. Sofrito: Sauce made with tomato and onion, leek, or garlic and sautéed in olive oil.
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As in our study, Rivellese et al reported that people with type II diabetes in Italy had adequate consumption of mono- and poly-unsaturated fats, but excess consumption of saturated fats and low fiber intake [12]. In another study conducted in six Mediterranean countries, Thanapoulou et al reported low consumption of carbohydrates and fiber among diabetic participants [17].

In comparison with the ENRICA study, diabetic subjects aged 51–84 in the 1999–2000 NHANES showed higher ADA-based compliance with the goals for intake of protein (70%) and cholesterol (49%) [9]. Likewise, diabetic persons in the 1999–2002 NHANES were seen to have higher compliance with intake of proteins (64%) and saturated fats (48%) [10]. In contrast, in both studies fiber intake was lower than in the ENRICA study. This may be due to greater focus on controlling saturated fat and cholesterol intake in the US diet than in Spain, and to higher fruit and vegetable consumption in Spain than in the US [31,33,36].

Our results suggest that diet quality in persons with diabetes in Spain has improved in the last decade. In a study conducted in the year 2000 in four outpatient diabetes clinics [13], less than 10% of diabetic patients consumed <10% of energy in the form of saturated fat and <8% ingested <300 mg/day of cholesterol, versus 37% and 48%, respectively, in the ENRICA study. Moreover, fiber intake was lower than in ENRICA.

As expected, higher accordance with dietary recommendations and, in particular, with the MD was associated with better glycemic control. This suggests that clinical trial evidence on the efficacy of MD can be translated into effective interventions within routine clinical practice with unselected diabetic populations [4]. Other cross-sectional analyses with clinic-based samples have also observed an association between the MD and glycemic control in diabetic subjects [37,38].

Finally, we should note the lack of differences between persons with diagnosed and undiagnosed diabetes in the level of accordance with the EASD and MD recommendations. This suggests problems in the implementation of nutritional guidelines, in education in diabetes management, and in self-care of diabetic patients in Spain. Future investigations should examine the barriers in clinical practice to nutritional education and the determinants of proper nutrition in diabetic individuals.

Limitations

This study has certain strengths and methodological limitations. Among its strengths are that it was conducted in a representative sample of an entire country, glucose was measured in a central laboratory, and a validated instrument was used to measure the diet.

One of its limitations is the cross-sectional design, which does not allow to infer causality for some of the associations found (e.g., lower HbA1C with increasing adherence to the MD). The cross-sectional design or insufficient statistical power may also have impeded observation of associations that would be expected a priori, such as the association between adherence to EASD or MD recommendations and less obesity. The response rate (51%) in the ENRICA study is also a cause of concern, although it should be noted that it is among the highest of the National Health Interview and Examination Surveys conducted in Europe [39]. However, we

Table 3. Variables associated with accordance with Mediterranean Diet.

	Accordance with Mediterranean Diet	
	% (95% CI)	Odds ratio (95% CI) [a]
Sex		
Male	62.1 (55.6–68.5)	1.00 (Ref.)
Female	50.7 (43.4–58.1)	0.60 (0.41–0.89)
Age, years		
18–44	38.8 (20.8–57.2)	1.00 (Ref.)
45–64	58.7 (50.4–67.1)	2.21 (0.95–5.14)
≥65	59.0 (52.9–65.2)	2.46 (1.09–5.54)
p for trend		0.070
Educational level		
Primary school or less	55.1 (48.8–61.3)	1.00 (Ref.)
Secondary school	59.0 (49.4–68.6)	1.23 (0.76–1.99)
University	62.7 (51.3–74.1)	1.33 (0.77–2.31)
p for trend		0.251
Smoking		
Never smokers	55.9 (49.2–62.6)	1.00 (Ref.)
Past smokers	58.1 (50.3–65.9)	0.75 (0.47–1.20)
Current smokers	60.9 (49.5–72.4)	1.00 (0.55–1.80)
Physical activity, METs-h/week		
Tertile 1 (<13.5)	51.1 (43.0–59.1)	1.00 (Ref.)
Tertile 2 (≥13.5 to <26.3)	60.7 (52.6–68.7)	1.42 (0.89–2.25)
Tertile 3 (≥26.3)	60.3 (51.5–69.1)	1.43 (0.86–2.36)
p for trend		0.158
Hours spent watching TV, h/week		
Tertile 1 (<14)	55.1 (45.7–66.5)	1.00 (Ref.)
Tertile 2 (≥14 to <21)	63.9 (54.9–73.1)	1.45 (0.86–2.47)
Tertile 3 (≥21)	55.3 (48.3–62.3)	0.98 (0.60–1.59)
p for trend		0.842
Body mass index, kg/m^2		
<25	53.8 (41.2–66.4)	1.00 (Ref.)
25–29.9	59.3 (51.6–67.0)	1.12 (0.61–2.05)
≥30	56.9 (50.0–63.7)	1.06 (0.59–1.93)
p for trend		0.946
Abdominal obesity		
No	63.9 (55.8–72.0)	1.00 (Ref.)
Yes	55.1 (49.3–60.9)	0.73 (0.48–1.11)
Hypertension		
No	54.1 (46.6–61.6)	1.00 (Ref.)
Yes	59.9 (53.8–66.1)	1.23 (0.83–1.82)
Diabetes treatment		
Oral	58.1 (56.2–64.0)	1.00 (Ref.)
Insulin	56.5 (40.7–72.3)	1.20 (0.60–2.43)
Oral+Insulin	55.8 (41.1–70.6)	0.93 (0.48–1.81)
Without drug treatment	55.9 (41.8–70.2)	0.95 (0.52–1.76)

[a]Odds ratio adjusted for sex and age.
n = 609.
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cannot rule out that those who were more health-conscious were more inclined to participate. As a result, the accordance with nutritional guidelines among diabetic adults observed in this study could even be higher than the actual one. Although observed

Table 4. Association of accordance with EASD diet, ADA diet and Mediterranean Diet with glycemic control.

	HbA1c <7%		
	% (95% CI)	Odds ratio (95% CI)[a]	Odds ratio (95% CI)[b]
Accordance with EASD			
No	49.9 (44.2–55.6)	1.00 (Ref.)	1.00 (Ref.)
Yes	50.1 (44.4–55.8)	1.13 (0.73–1.74)	1.06 (0.66–1.70)
Accordance with ADA			
No	50.9 (45.5–56.2)	1.00 (Ref.)	1.00 (Ref.)
Yes	49.1 (43.8–54.5)	1.37 (0.91–2.10)	1.34 (0.87–2.07)
Accordance with MD			
No	38.6 (32.9–42.3)	1.00 (Ref.)	1.00 (Ref.)
Yes	61.4 (55.7–67.1)	1.61 (1.05–2.47)	1.56 (1.1–2.45)

[a]Model adjusted for sex and age.
[b]Model adjusted for sex, age, educational level, smoking, physical activity, hours spent watching TV, body mass index, abdominal obesity, hypertension and diabetes treatment.
n = 609.
doi:10.1371/journal.pone.0039454.t004

sodium intake was excessive, it is also likely to be an underestimate because self-reported intakes are usually lower that those derived from 24-h urinary sodium excretion [40]. Another limitation is that the definition of diabetes was based on a single blood glucose measure, and the diagnosis of diabetes was self-reported, which means that classification error cannot be excluded. Finally, there are several scales to measure the MD, and the results may vary according to the scale used. However, the MEDAS was specifically developed and validated in a Spanish population [23].

Conclusions

Our study shows an important gap between the nutritional recommendations of scientific societies and the diet in diabetic individuals in Spain. Moreover, the lack of dietary differences between diagnosed and undiagnosed persons points to deficiencies in the health care system, both in nutritional education for diabetic patients and in support for self-care. Finally, diabetic patients in Spain should reduce their intake of saturated fats, cholesterol, sugar and salt, and should increase their intake of complex carbohydrates and fiber.

Author Contributions

Conceived and designed the experiments: MMP FRA. Analyzed the data: MMP LMLM PGC. Wrote the paper: MMP FRA. Contributed to data interpretation: MMP LMLM PGC AG ELG JRB FRA. Reviewed the manuscript for important intellectual content: MMP LMLM PGC AG ELG JRB FRA. Read and approved final manuscript: MMP LMLM PGC AG ELG JRB FRA. Primary responsibility for final content: FRA.

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7. ARTÍCULO 3: Food sources of sodium, saturated fat and added sugar in the Spanish hypertensive and diabetic population

Fuentes de alimentos de sodio, grasas saturadas y azúcares añadidos en la población Española hipertensa y diabética.
(Atherosclerosis 2013: 198-205)

Antecedentes: Investigaciones previas han mostrado que la dieta de pacientes hipertensos y diabéticos tiene un bajo acuerdo con las principales recomendaciones dietéticas, sobre todo debido a la alta ingesta de sodio, grasas saturadas y azúcares añadidos. Este es el primer estudio que identifica las principales fuentes de estos nutrientes en estos pacientes.

Métodos: Estudio transversal realizado en 2008-2010 en una muestra representativa de la población adulta Española, incluyendo 2,323 pacientes con hipertensión y 635 con diabetes. La dieta habitual fue medida usando una historia dietética validada. La ingesta de sodio, grasas saturadas y azúcares añadidos fue estimada con tablas de composición de alimentos Españoles.

Resultados: La población hipertensa y diabética mostró, respectivamente, una ingesta de 2.9 y 3.1 g/día de sodio, 26 y 26 g/día de grasas saturadas, y 33 y 24 g/día de azúcares añadidos. En pacientes hipertensos y diabéticos, respectivamente, la mayoría de la ingesta de sodio provino del pan (35%, 34%), embutidos crudos-curados (15%, 15%), embutidos cocidos (6%, 7%) y sopas (5%, 6%). Las principales fuentes de grasas saturadas fueron el queso curado (13%,13%), bollería (12%, 11%), carnes rojas (10%, 11%), embutidos crudos-curados (8%, 9%) y la leche entera (4%, 4%). Los grupos de alimentos que más contribuyeron a los azúcares añadidos fueron la azúcar agregada directamente al café y otras bebidas (27%, 19%), la bollería (15%, 19%), los refrescos azucarados (10%, 13%) y el yogurt entero (9%, 12%). Las principales fuentes de nutrientes fueron similares en ambos sexos y grupos de edad.

Conclusión: En pacientes con hipertensión y diabetes, la ingesta de sodio, grasas saturadas y azúcares añadidos puede ser substancialmente reducida priorizando las variedades de pan bajos en sal, reduciendo el consumo de bollería y embutidos, reemplazando los quesos curados u otros productos lácteos enteros por productos bajos en grasa, usando edulcorantes y sustituyendo los refrescos azucarados por refrescos sin azúcar o simplemente agua.

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Food sources of sodium, saturated fat and added sugar in the Spanish hypertensive and diabetic population

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ABSTRACT

Objectives: Previous research has shown that the diet of hypertensive and diabetic patients has a low accordance with the main nutritional recommendations, mostly due to the high intake of sodium, saturated fat and added sugars. This is the first study to identify the main food sources of these nutrients in these patients.
Methods: Cross-sectional study conducted in 2008–2010 in a representative sample of the Spanish adult population, including 2323 patients with hypertension and 635 with diabetes. The habitual diet was assessed using a validated diet history. The intake of sodium, saturated fat and added sugars was estimated with Spanish food composition tables.
Results: The hypertensive and diabetic population showed, respectively, an intake of 2.9 and 3.1 g/day of sodium, 26 and 26 g/day of saturated fat, and 33 and 24 g/day of added sugar. In hypertensive and diabetic patients, respectively, most sodium intake came from bread (35%, 34%), raw-cured sausages (15%, 15%), cooked sausages (6%, 7%), and soup (5%, 6%). The main sources of saturated fat were cured cheese (13%, 13%), bakery products (12%, 11%), red meat (10%, 11%), raw-cured sausages (8%, 9%) and whole milk (4%, 4%). The food groups that most contributed to added sugar intake were sugar directly added to coffee and other beverages (27%, 19%), bakery products (15%, 19%), sugary soft drinks (10%, 13%), and whole yogurt (9%, 12%). The main food sources of nutrients were similar in all sex and age groups.
Conclusions: In patients with hypertension and diabetes, the intake of sodium, saturated fat and added sugar can be substantially reduced by prioritizing low-salt varieties of bread, reducing the consumption of bakery products and sausages, replacing cured cheese and other whole dairy products by low-fat products, using non-sugary sweeteners, and substituting sugar-free soft drinks, or plain water, for sugary sodas.

1. Introduction

Hypertension and diabetes mellitus are two major public health problems due to their high frequency and their association with increased risk of cardiovascular disease, premature disability and death [1,2]. In Spain, a third of the adult population is hypertensive and less than 25% of these individuals have blood pressure controlled [3]. In addition, 12% of adults have diabetes [4], of which just over half reach the glycemic target [5]. This is important because poor control of blood pressure and glucose is associated with macrovascular complications in both groups of patients [6–8], and microvascular complications in diabetics [8].

Nutritional therapy is a key component of appropriate management of blood pressure and glucose levels in these patients [9–11]. However, a recent population-based study in Spain has shown that the diet of hypertensive and diabetic patients has a low accordance with the main nutritional recommendations, mostly due to the high intake of sodium, saturated fat and added sugars [12,13].

To our knowledge, no previous study has conducted a comprehensive analysis of the food sources of nutrients in a hypertensive or diabetic population in Europe. This work identifies the main food sources of sodium, saturated fat and added sugars in a representative sample of hypertensive and diabetic patients in Spain. This information may serve to implement changes in the diet of these

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patients to reduce inappropriate nutrient intake and, thus, improve blood pressure and glycemic control.

2. Methods

2.1. Study design and participants

The data were taken from the Study of Nutrition and Cardiovascular Risk in Spain (ENRICA), whose methods have been reported elsewhere [14]. This is a cross-sectional study conducted from June 2008 to October 2010 with 12,948 individuals representative of the non-institutionalized Spanish population aged 18 and over. Data were collected at the homes of study participants. Information was obtained by an interview on lifestyle, a physical exam to measure blood pressure and anthropometry, collection of blood and urine samples, and a dietary history to assess usual food consumption.

Study participants gave written informed consent. The study protocol was approved by the Clinical Research Ethics Committee of Hospital La Paz in Madrid and the Clínic Hospital in Barcelona.

2.2. Study variables

2.2.1. Hypertension

Blood pressure was measured, using standardized procedures, with validated automatic devices (model Omron M6) and cuffs of three sizes according to arm circumference [12]. Two sets of readings were made separated by 90 min. In each set, blood pressure was measured three times at 1–2 min intervals, after the individual had rested for at least 3–5 min in a seated position (or, if not possible, then lying face up). In the analyses, blood pressure was calculated as the mean of at least 3 out of the last 5 readings. Hypertension was defined as systolic pressure ≥140 mm Hg, diastolic pressure ≥90 mm Hg, or being treated with antihypertensive drugs. Because diet therapy is prescribed only to those with diagnosed hypertension, we restricted this analysis to individuals who answered affirmatively to the following question: "Have you ever been told by the doctor that you had hypertension, also called high blood pressure?"

2.2.2. Diabetes mellitus

Twelve-hour fasting blood glucose was measured using the oxidase glucose technique (ADVIS 2400 Chemistry System analyzer, Siemens). Diabetes mellitus was defined as glucose ≥126 mg/dl or use of antidiabetic medication. The analyses included only diabetic subjects who responded affirmatively to the question: "Have you ever been told by the doctor that you had diabetes or elevated blood sugar?" [13].

2.2.3. Diet

Usual food consumption in the previous year was ascertained with an electronic dietary history, developed from that used by the EPIC-Spain cohort study [15,16]. Specifically, we asked about food consumption in a standard week, and recorded all food eaten at least once every 15 days. The dietary history took into account seasonal and weekend food consumption.

Study participants reported the consumption of 880 different foods, which were classified into groups according to nutritional content. For the analyses of sodium intake, some sodium-rich foods like packaged fried tomato sauce, common salt added to food mixtures during cooking, and olives were analyzed separately. However, salt added at the table or that contained in water was not considered. For the analyses of the intake of added sugars, we considered only the 181 foods containing this nutrient, which were classified into groups of relatively homogeneous composition. Table 1 includes a detailed description of the food sources that contributed to at least 1% of the intake of the nutrients considered in this study.

Intake of sodium, saturated fat and added sugar was calculated using standard composition tables [17–21] and the information provided in some packaged food labels.

2.3. Statistical analysis

Among the 12,948 study participants, we excluded 873 who lacked blood pressure data and 221 without glucose data. Of these, we selected the 3995 individuals with hypertension and, among them, the 2367 who were aware of their condition. Likewise, we selected the 876 diabetics and, among them, the 696 diagnosed diabetics. Finally, we excluded the individuals whose diet was outside the valid range (≤800 or ≥5000 kcal/day in men; ≤500 or ≥4000 kcal/day in women) and those with missing information on the remaining study variables. As a result, the analyses were performed with 2323 hypertensives and 635 diabetics.

The statistical analyses mostly used a descriptive approach. The population percentage of a given nutrient (sodium, saturated fat, or added sugar) that is contributed by any single food or food group was calculated as follows: [(target nutrient contributed by a specific food or food group for all individuals/target nutrient contributed by all foods for all individuals) × 100] [22]. We present data only for those foods/food groups that contributed at least 1% of the total nutrient intake.

The analyses were conducted with the total study sample, and separately by sex and three age groups. To assess group differences we used the chi square test, and statistical significance was set at 2-tailed $p < 0.05$. Individual observations were weighted to reconstruct the Spanish population. The analyses were performed with SAS (version 9.2, SAS Institute Inc, Cary, NC).

3. Results

Total energy intake was 2063 (SD 636) kcal/d among the hypertensives, and 2055 (SD 635) kcal/d among the diabetics. The hypertensive population showed an intake of 2.9 g/day of sodium, 26 g/day of saturated fat, and 33 g/day of added sugar (Table 2). As a result, only 10% met the recommended intake of sodium (<1.5 g/day), 8% of saturated fat (<7% of energy) and 9% of sugars (<10% of energy). Among the diabetics, the intake was 3.1 g/day for sodium, 26 g/day for saturated fat, and 24 g/day for added sugar. Corresponding figures for meeting the recommended nutrient intake were 9%, 8% and 11%, respectively. In both the hypertensives and the diabetics, the intake of sodium, saturated fat and added sugar was higher in men and in the youngest individuals (Table 3).

Fig. 1 shows that in both types of patients most sodium intake came from bread (about 35%) and raw-cured sausages (about 15%). Other important sources of sodium were cooked sausages (about 6%), soup (about 5%) and olives (about 4%). These foods were the main sodium sources regardless of sex and age (Table 3). It is of note that packaged foods (without considering olives and commercial fried tomato sauce) only contributed to 2.3% and 2.1% of total sodium intake in hypertensives and diabetics, respectively; the corresponding figures for precooked dishes were about 0.3% in both hypertensives and diabetics. No substantial differences were found in the sources of sodium between the hypertensive or diabetic individuals and those free of these diseases. (See Supplementary Table 1).

As regards saturated fat, the main sources were cured cheese, baked goods, pastries and cookies, red meat, raw-cured sausages and, to a lesser extent, whole milk. Together they contributed to 48% of saturated fat among both the hypertensives and the

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Table 1
Food group classification for food sources that contributed to at least 1% of the intake of the nutrients considered in the ENRICA study, 2008–2010.

	Food group	Components
1	Bread	White bread, wholegrain bread, breadstick, sliced white breads, hamburger buns, hotdog buns, and Vienna white breads.
2	Breakfast cereals	Wheat cereal, corn cereal, rice cereal, oatmeal, and muesli. **Sugary cereals were only considered in foods with added sugar.*
3	Egg and egg products	Egg and omelettes.
4	Whole milk and milkshake	Whole milk, cream, and milkshake.
5	Semi-skimmed milk	
6	Skimmed milk	
7	Whole yogurt and fermented milk	Regular yogurt, liquid yogurt, and whole fermented milk. **Sugary yogurts and sugary fermented milks were only considered in foods with added sugar.*
8	Dairy desserts	Mousse, custard, and ice cream.
9	Fresh cheese	Fresh cow cheese, fresh goat cheese, and fresh sheep cheese.
10	Cured cheese	Cured or semi-cured cow cheese, cured or semi-cured goat cheese, and cured or semi-cured sheep cheese.
11	Cheese spread	All type of cheese spread
12	Red meat	Veal, beef, pork, lamb, goat, horse and wild boar.
13	White meat	Chicken, quail, pheasant, goose, duck, turkey, pigeon, and partridge.
14	Raw-cured sausages	Raw or cured seasoned pork sausages and cured hams.
15	Cooked sausages	Cooked seasoned pork and poultry sausage, cooked hams, bacon and paté.
16	Processed meat	Meatballs and hamburgers.
17	White fish	Pollack, weever, blue whiting, cod, sea bream, red scorpionfish, dogfish, black seabream, ribbon fish, gilthead seabream, pouting, megrim, halibut, common sole, seabass, whiting, hake, grouper, flathead mullet, common pandora, young hake, catshark, plaice, angler, blonde ray, turbot, red mullet, white seabream, and blue shark.
18	Oily fish	Anchovy, sardine, eel, herring, tuna, albacore, Atlantic horse mackerel, Atlantic mackerel, transparent goby, conger, swordfish, pomfret, and salmon.
19	Vegetables	Chard, celery, watercress, collard green, borage, spinach, cabbage, endive, lettuce, thistle, scallion, fennel, onion, leek, garlic, asparagus, palm heart, turnip, parsnip, radish, beet, soy, carrot, artichoke, eggplant, broccoli, cauliflower, zucchini, pumpkin, green been, corn, pepper, tomato, champignon, and mushroom.
20	Cooked fruits and vegetables	Sugary apple compote, sugary baked apple, and canned corn.
21	Olives	Black olives and green olives.
22	Nuts	Almond, hazelnut, walnut, pistachio, peanut, pines, chestnut, cashew, and seeds.
23	Soups	Vegetable soup, poultry soup, meat soup, and fish soup.
24	Common salt	
25	Commercial fried tomato sauce	
26	Soft drinks	Sugary orange soda, sugary cola soda, sugary lemon-lime soda, tonics, and energy drinks.
27	Fruits juices and nectars	Different fruit flavors of sugary juice and sugary nectars.
28	Fats	Lard, margarine, and butter.
29	Sugar, honey and syrup	White sugar, brown sugar, fructose, honey, and syrup.
30	Jam and jelly	Different fruit flavors of sugary jam, and different fruit flavors of jellies.
31	Baked goods, pastries and cookies	Sweet buns, cakes, sponge cakes, tarts, croissants, donuts and all types of sugary cookies.
32	Chocolate	Milk chocolate, chocolate with nuts, white chocolate, dark chocolate and powdered cocoa.
33	Candy	Hard candy, sugary chewing gum, glazed almonds, licorice candy, and sweet gummies.

diabetics (Fig. 2). These foods were the main sources of saturated fat in all sex and age groups, though their relative importance varied slightly between groups in the diabetics (Table 4). About 11% of saturated fat came from oils, mostly olive oil, in both types of patients. Although olive oil is not rich in saturated fat, it is an important source of this nutrient because of its high consumption in Spain. However, we decided not to include this information in Fig. 2 because olive oil has a good ratio of monounsaturated to saturated fat, and provides substantial health benefits, including improved control of blood pressure and glucose [23]. Therefore, a reduction of olive oil consumption is not a reasonable means of limiting saturated fat intake. No important differences were found in the sources of saturated fat between the hypertensive or diabetic individuals and those free of these diseases. (See Supplementary Table 2).

Table 2
Average intake of sodium, saturated fat, and added sugar in the Spanish diagnosed hypertensive and diabetic population.[a]

	Sodium g/day	Saturated fat g/day	Added sugar g/day
Diagnosed hypertensives, $N = 2323$			
All	2.9 (1.3)	26 (12)	33 (32)
Sex			
Men	3.3 (1.3)	29 (13)	36 (34)
Women	2.5 (1.2)	22 (10)	30 (29)
Age, years			
18–44	3.5 (1.2)	33 (14)	51 (38)
45–64	3.1 (1.4)	28 (13)	36 (35)
≥65	2.6 (1.2)	23 (10)	26 (25)
Diagnosed diabetics, $N = 635$			
All	3.1 (1.4)	26 (12)	24 (27)
Sex			
Men	3.4 (1.3)	28 (12)	25 (27)
Women	2.7 (1.4)	23 (11)	23 (27)
Age, years			
18–44	3.5 (1.2)	30 (10)	44 (34)
45–64	3.4 (1.5)	28 (12)	27 (29)
≥65	2.8 (1.3)	24 (12)	20 (24)

[a] Values are means (standard deviation).

Finally, the food groups with the greatest contribution to added sugar intake were sugar, honey and syrups, baked goods, pastries and cookies, sugary soft drinks, and whole yogurt and other fermented milk. These four food groups accounted for 61% of added sugar in hypertensives and 64% in diabetics (Fig. 3). As expected, white sugar directly added to food (e.g., coffee and tea) was a more important source of added sugar in hypertensives (26.9%) than in diabetics (19.4%). Also, chocolate contributed substantially to added sugar (11%) in hypertensives. Table 5 shows that sugary soft drinks represented the second leading source of added sugar (17%) in the youngest hypertensives and the most important source in the youngest diabetics (26%). The importance of soft drinks as a source of added sugar was lower among the hypertensive individuals than in those free of hypertension; also the contribution of sugar, honey

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Table 3
Top five food sources of sodium in the Spanish diagnosed hypertensive and diabetic population, by sex and age.

	Sex				Age, *years*					
	Men		Women		18–44		45–64		≥65	
	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%
Diagnosed hypertensives, $N = 2323$										
Bread	1	34.2	1	35.9	1	32.7	1	34.5	1	36.1
Raw-cured sausages	2	17.3**	2	11.4**	2	15.2	2	16.6	2	13.0
Cooked sausages	3	5.4	4	5.6	3	7.6	3	5.5	4	4.8
Soups	4	4.9	3	5.7	4	4.1	4	4.7	3	6.2
Cured cheese	5	4.0	–	–	–	–	–	–	5	3.9
Olives	–	–	5	3.5	5	3.7	5	4.0	–	–
Diagnosed diabetics, $N = 635$										
Bread	1	33.7	1	34.7	1	32.7	1	35.1	1	34.3
Raw-cured sausages	2	16.9*	2	11.2*	2	12.8	2	15.7	2	14.8
Cooked sausages	3	6.8	3	7.30	3	8.0	3	5.5	3	6.6
Soups	4	5.4	4	6.5	4	5.2	4	4.1	4	6.0
Olives	5	4.4	5	3.6	5	5.1	5	3.9	5	4.3

*$p < 0.05$; **$p < 0.001$.

and syrup to total added sugar was lower among the individuals with diabetes than in those without (See Supplementary Table 3).

4. Discussion

Our results show that a few foods account for a substantial part of the high intake of sodium, saturated fat and added sugars in hypertensive and diabetic patients in Spain. Furthermore, some of these foods are important sources of more than one nutrient; in particular raw-cured sausages contribute to excess intake of sodium and saturated fats, while bakery products are one of the main sources of saturated fat and added sugars. Therefore, a few relatively simple dietary changes may translate into a large improvement in the nutritional quality of the diet of these patients.

Half of sodium intake comes from bread and sausages. Although bread is not very rich in sodium, the high consumption of bread in hypertensives (160 g/day) and in diabetics (164 g/day) makes it the main source of sodium. The Ministry of Health of Spain has recently

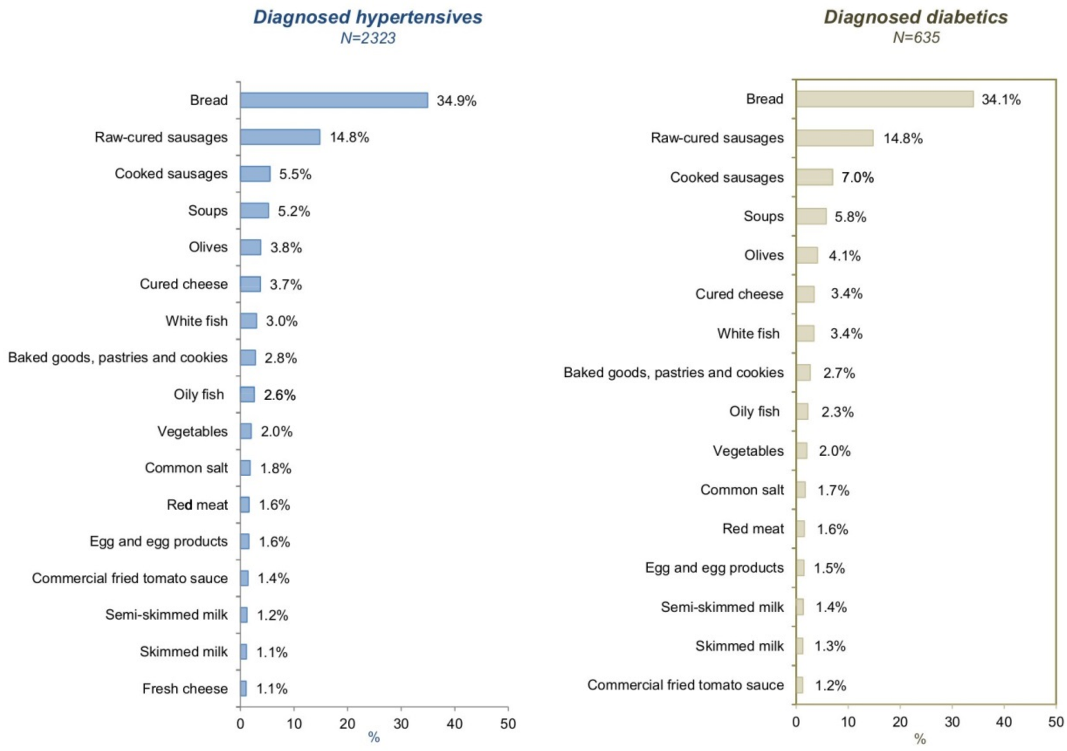

Fig. 1. Food sources of sodium in the Spanish diagnosed hypertensive and diabetic population.

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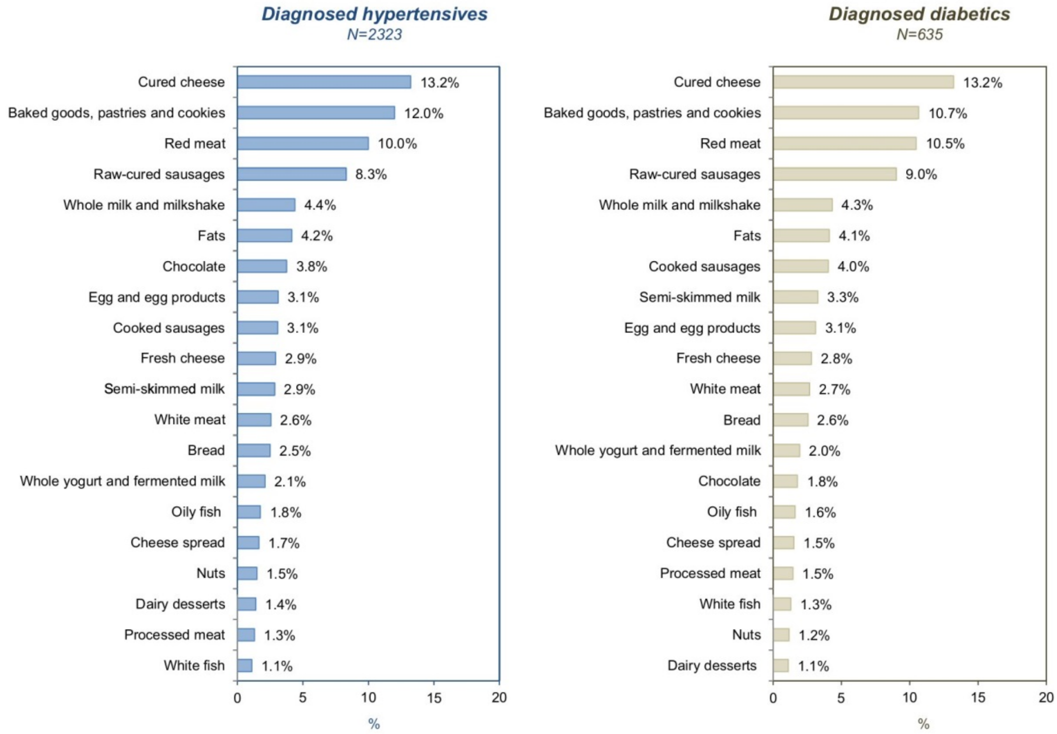

Fig. 2. Food sources of saturated fat in the Spanish diagnosed hypertensive and diabetic population (oils were not plotted).

agreed with the business sector to gradually reduce the sodium content in bread and sausages by 10% [24]. This is important because it can help improve the diet without requiring changes in patients' behavior. As a complement to this public health intervention, nutritional counseling by health professionals is also crucial because bread does not taste salty, so patients may be unaware that this is the main source of sodium in the diet. Therefore, patients should be counseled to buy those varieties of bread and sausages with low sodium content, which are beginning to be available in many retail stores in Spain. Good food labeling may also help make purchasing decisions easier.

Contrary to what is observed in other European countries, Canada and the United States, packaged and precooked foods are not an important source of sodium in Spain [25–27]. This is because of the high price of these foods in Spain, so they are not a regular diet component. The main sources of sodium vary between

Table 4
Top five food sources of saturated fat in the Spanish diagnosed hypertensive and diabetic population, by sex and age.

	Sex				Age, *years*					
	Men		Women		18–44		45–64		≥65	
	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%
Diagnosed hypertensives, $N = 2323$										
Cured cheese	1	13.9	1	12.2	1	11.6	1	12.6	1	14.4
Red meat	2	10.7	3	9.00	3	10.3	3	10.4	3	9.6
Baked goods, pastries and cookies	3	10.5	2	11.8	2	10.4	2	11.3	2	11.4
Raw-cured sausages	4	10.1*	4	5.7*	4	8.6	4	9.7	4	6.8
Whole milk and milkshake	5	4.5	–	–	5	5.9	–	–	5	4.4
Chocolate	–	–	5	4.7	–	–	5	4.4	–	–
Diagnosed diabetics, $N = 635$										
Cured cheese	1	14.2	1	11.4	2	9.6	1	13.6	1	13.5
Red meat	2	11.6	3	8.7	1	11.0	2	11.2	3	9.8
Baked goods, pastries and cookies	4	9.3	2	13.0	5	7.0	3	10.3	2	11.5
Raw-cured sausages	3	11.1	5	5.5	4	8.3	4	9.9	4	8.5
Whole milk and milkshake	5	4.0	–	–	–	–	5	4.5	5	4.5
Fats	–	–	4	5.9	3	8.5	–	–	–	–

*$p < 0.05$.

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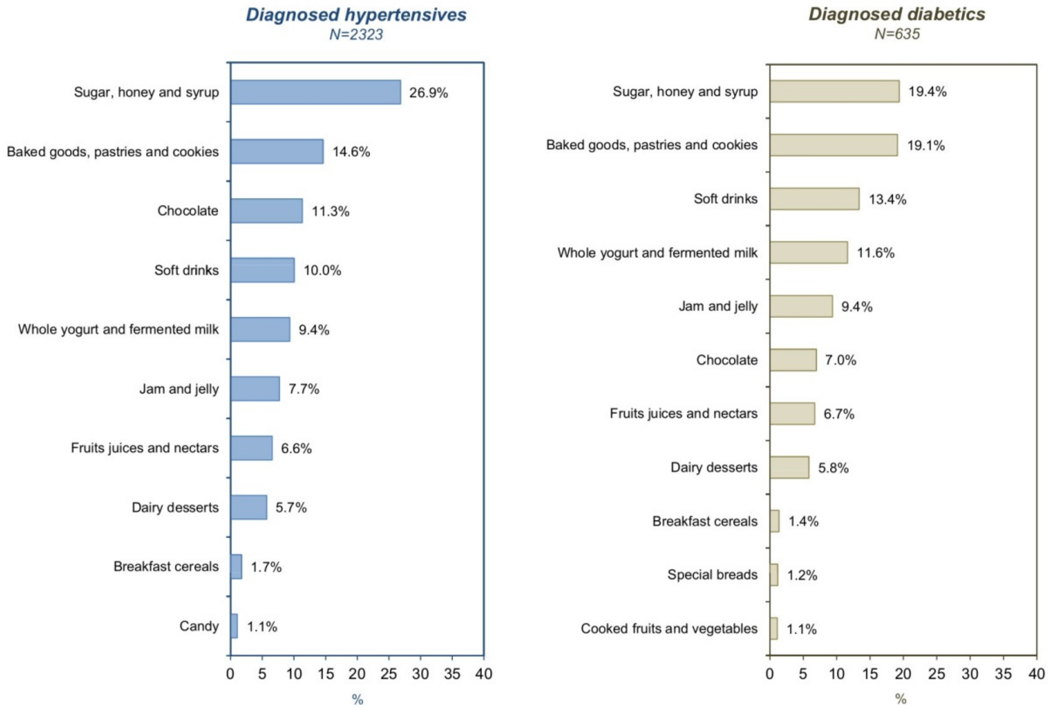

Fig. 3. Food sources of added sugar in the Spanish diagnosed hypertensive and diabetic population.

countries according to their eating habits, cooking procedures, and socioeconomic development. While in China most dietary salt is added in home cooking, in most developed countries the main source of salt is processed food. Specifically, in Japan the main sources are soy sauce and commercially processed fish/seafood, whereas in the United Kingdom, Canada and the USA the most important sources are processed breads/cereals/grains [25–27]. Therefore, studies should be conducted at the local or country level to identify the food sources of sodium for which appropriate interventions can be designed.

Cure cheese and whole milk provided nearly 20% of the saturated fat in the hypertensive and diabetic population. It is therefore possible to reduce the intake of this nutrient by prioritizing consumption of low-fat cheese and skim or low-fat milk; in fact the DASH-diet, a diet rich in fruits, vegetables and low-fat dairy products, and relatively low in saturated and total fat, has been shown to reduce blood pressure in hypertensive individuals [28]. The next most important sources of saturated fat were bakery products and red meat and sausages. As regards added sugars, the leading sources were sugar directly added to beverages, bakery products

Table 5
Top five food sources of added sugar in the Spanish diagnosed hypertensive and diabetic population by sex and age.

	Sex				Age, *years*					
	Men		Women		18–44		45–64		≥65	
	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%
Diagnosed hypertensives, $N = 2323$										
Sugar, honey and syrup	1	28.1	1	25.3	1	24.6	1	28.4	1	26.3
Baked goods, pastries and cookies	2	13.3	2	15.1	4	11.4	2	13.4	2	17.6
Chocolate	3	10.9	3	11.9	3	11.9	3	12.9	5	9.4
Soft drinks	4	10.7	4	9.2	2	16.7	4	10.4	–	–
Whole yogurt and fermented milk	5	9.5	5	9.2	5	11.3	5	8.1	4	9.8
Jam and Jelly	–	–	–	–	–	–	–	–	3	9.9
Diagnosed diabetics, $N = 635$										
Sugar, honey and syrup	1	22.1*	2	15.4*	2	20.3	1	25.4	3	13.8
Baked good, pastries and cookies	2	16.5	1	23.0	4	8.4	2	18.5	1	22.7
Soft drinks	3	16.4	5	8.8	1	26.3	3	13.6	5	9.6
Whole yogurt and fermented milk	4	10.4	3	13.5	–	–	4	8.7*	2	15.2*
Jam and Jelly	5	7.8	4	11.8	3	11.9	5	7.9	4	10.0
Fruits juices and nectars	–	–	–	–	5	8.1	–	–	–	–

*$p < 0.05$.

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and sugary soft drinks. Previous research in the general population in the USA has obtained fairly similar results: the main sources of solid fat (mostly saturated) were grain-based desserts, cheese and sausages, and the main sources of added sugar were soft drinks and grain-based desserts [29].

Our results are noteworthy because dietary guidelines for the general population strongly recommend reducing the consumption of many of the above-mentioned foods [30,31]. Accordingly, our findings show shortcomings in the public health nutrition strategies in Spain; notwithstanding this, the Spanish Ministry of Health has recently agreed with meat producers to reduce the saturated fat in processed meat and sausages by 5% in the subsequent 2 years [32]. Moreover, given that nutritional recommendations for diabetes treatment clearly emphasize a low consumption of bakery products and sugar [10,11], our study points to serious deficiencies in the nutritional therapy of diabetic patients within the healthcare system. Fortunately, the diet of hypertensive and diabetic patients could be improved by simple dietary changes, like reducing the consumption of bakery products and processed meat, adding non-sugary sweeteners instead of sugar to coffee and other beverages, and switching to non-sugary soft drinks and plain water.

This study has some limitations and strengths. Among the first is that dietary surveys usually underestimate the total intake of energy and nutrients, especially in people who are overweight [33], whose prevalence is very high in Spain [34]. Underestimation of nutrient intake is even more important for sodium, because we did not consider the salt added at the table or provided by tap/mineral water and other drinks, which represents about 10% of total sodium intake in developed countries [35]. In any case, sodium intake in our study was about 70% of that registered in the only study in Spain which measured urinary sodium excretion (the gold standard) [36]. Therefore, the actual intake of sodium, saturated fat and added sugars is undoubtedly higher than that observed in our study, although this intake was already fairly high. However, this limitation should not necessarily alter the estimation of the relative importance of the various food sources of nutrients, which was the main objective of this work.

Second, our classification of food groups could have affected the study results. For instance, while in some previous studies pizza or pasta dishes and potato chips were a major source of salt [26,27], in ours most of the salt intake has been attributed to specific components of these foods; specifically, in pasta dishes most salt intake has been attributed to commercial tomato sauce, and in potato chips to the common salt added in cooking. Similarly, in our study the saturated fat ingested with French fries has been attributed to the frying oils.

And third, as in previous studies [25–27,29], we assumed that the food composition tables reliably reflected the available nutrients. Although we used the most current tables of food composition, the large variety of food in the market and the fact that food can be imported from different parts of the world could produce some errors in the estimation of nutrients, although it is unlikely that this has affected the relative ranking of the main nutrient sources.

The main strength of this study was the use of a representative sample of Spanish hypertensive and diabetic individuals, whose diagnosis was based on objective measurements obtained by standard procedures. Another strength was that dietary information was collected through a validated dietary history.

There is accumulating evidence that substantial health benefits and a reduction in medical costs can be achieved by lowering the dietary intake of sodium, saturated fat and added sugars in the general population [37–39] and in patients with hypertension and diabetes [9–11]. Within this context, our work has practical implications because it suggests that in hypertensive and diabetic patients the intake of these nutrients can be substantially reduced by acting on a few foods. Specifically, the focus should be placed on prioritizing the consumption of low-salt varieties of bread, reducing the consumption of bakery products and sausages, replacing cured cheese and other whole dairy products by skimmed or low-fat products, using non-sugary sweeteners, and substituting sugar-free soft drinks, or simply plain water, for sugary sodas.

Author contributions

PG-C and FR-A conceived the study. PG-C and MM-P conducted the data analysis. MM-P and FR-A drafted the manuscript. All authors contributed to interpretation of results and critically reviewed the manuscript for important intellectual content. PG-C and FR-A had primary responsibility for the final content. All authors read and approved the final manuscript. Conflict of interest: None of the authors had a personal of financial conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.atherosclerosis.2013.04.001.

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8. ARTÍCULO 4: Obesity-related eating behaviors are associated with higher food energy density and higher consumption of sugary and alcoholic beverages: A Cross-Sectional Study

Artículo aceptado en PLoS ONE 2013 (Pendiente de publicación).

Las conductas alimentarias relacionadas con la obesidad están asociadas a la ingesta de alimentos con alta densidad energética y a un elevado consumo de bebidas alcohólicas y azucaradas: Un estudio transversal.

(PLoS ONE 2013; Pendiente de publicación)

Antecedentes: Las conductas alimentarias relacionadas con la obesidad se asocian a una mayor ingesta energética. La ingesta total de energía se puede descomponer en los siguientes constituyentes: tamaños de la porción, densidad energética de los alimentos, número de ocasiones de ingesta, y la ingesta energética que proviene de bebidas ricas en energía. Hasta donde conocemos este es el primer estudio que examina la asociación entre las conductas alimentarias relacionadas con la obesidad y estos componentes de la energía.

Métodos: Los datos fueron tomados de un estudio transversal realizado en 2008-2010 en 11.546 individuos representativos de la población Española no institucionalizada de 18 años y más. Se recogió información auto-reportada de las siguientes 8 conductas alimentarias relacionadas con la obesidad: no planear cuanto comer antes de sentarse a la mesa, consumir alimentos enlatados o precocinados, comprar snacks en máquinas expendedoras, comer en restaurantes de comida rápida, no seleccionar alimentos bajos en calorías, no quitar la grasa visible de la carne o la piel del pollo antes de comerla, y comer viendo TV. La dieta habitual fue evaluada con una historia dietética validada. Los análisis fueron conducidos mediante regresión lineal ajustando por los principales confusores.

Resultados: En comparación con los individuos con ≤1 conductas alimentarias relacionadas con la obesidad, aquellos con 5 o más consumieron alimentos con mayor densidad energética (β 0.10; IC 95% 0.08, 0.12 kcal/g/día; p tendencia <0.001), y mostraron un mayor consumo de bebidas azucaradas (β 7; 95% CI -7, 20 ml/day; p-trend <0.05), y de bebidas alcohólicas (β 24; IC 95% 10, 38 ml/día; p tendencia <0.001). Específicamente, un mayor número de conductas alimentarias relacionadas con la obesidad se asoció con una mayor ingesta diaria de productos lácteos y carnes rojas, y con un menor consumo de frutas frescas, pescados azules y carnes blancas. No se encontró asociación entre el número de conductas alimentarias y el tamaño de la porción o el número de ocasiones de ingesta.

Conclusiones: Las conductas alimentarias relacionadas con la obesidad están asociadas con una mayor ingesta de alimentos con elevada densidad energética, y con un mayor consumo de bebidas azucaradas y alcohólicas. Evitar estas conductas puede resultar difícil porque ellas están firmemente arraigadas en la sociedad. No obstante, estos resultados podrían servir para paliar los efectos indeseables de estas conductas alimentarias mediante la reducción de la ingesta energética asociada.

Obesity-related eating behaviors are associated with higher food energy density and higher consumption of sugary and alcoholic beverages: A Cross-Sectional Study.

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ABSTRACT

Objectives: Obesity-related eating behaviors (OREB) are associated with higher energy intake. Total energy intake can be decomposed into the following constituents: food portion size, food energy density, the number of eating occasions, and the energy intake from energy-rich beverages. To our knowledge this is the first study to examine the association between the OREB and these energy components.

Methods: Data were taken from a cross-sectional study conducted in 2008-2010 among 11,546 individuals representative of the Spanish population aged ≥18 years. Information was obtained on the following 8 self-reported OREB: not planning how much to eat before sitting down, eating precooked/canned food or snacks bought at vending machines or at fast-food restaurants, not choosing low-energy foods, not removing visible fat from meat or skin from chicken, and eating while watching TV. Usual diet was assessed with a validated diet history. Analyses were performed with linear regression with adjustment for main confounders.

Results: Compared to individuals with ≤1 OREB, those with ≥5 OREB had a higher food energy density (β 0.10; 95% CI 0.08, 0.12 kcal/g/day; p-trend <0.001) and a higher consumption of sugary drinks (β 7; 95% CI -7, 20 ml/day; p-trend <0.05) and of alcoholic beverages (β 24; 95% CI 10, 38 ml/day; p-trend <0.001). Specifically, a higher number of OREB was associated with higher intake of dairy products and red meat, and with lower consumption of fresh fruit, oily fish and white meat. No association was found between the number of OREB and food portion size or the number of eating occasions.

Conclusions: OREB were associated with higher food energy density and higher consumption of sugary and alcoholic beverages. Avoiding OREB may prove difficult because they are firmly socially rooted, but these results may nevertheless serve to palliate the undesirable effects of OREB by reducing the associated energy intake.

KEY WORDS: obesity, eating behavior, energy density, sugary beverages, alcoholic beverages, Spain.

INTRODUCTION

The main guidelines for weight control recommend avoiding or moderating the so called obesity-related eating behaviors (OREB), which include skipping breakfast, eating at fast-food restaurants, snacking, and eating while watching television (TV), among others [1-4]. In a previous study, we provided support for this recommendation because we showed that individuals with a higher number of OREB had a higher energy intake [5].

Total energy intake can be decomposed into the following constituents [6]: food portion size [7], food energy density (ED) [8-10], the number of eating occasions (EO) [11-12], and the energy intake from energy-rich beverages, like sugary and alcoholic drinks [13, 14]. To our knowledge, this is the first study to examine the association between the OREB and these energy components. Given that eliminating or moderating OREB may prove difficult because they are firmly socially rooted (e.g., eating at fast-food restaurants or eating while watching TV), this study is important because it may suggest ways to palliate the undesirable effects of OREB by reducing the associated energy intake.

SUBJECTS AND METHODS

Study design and participants

Data were taken from the Study on Nutrition and Cardiovascular Risk in Spain (ENRICA study), whose methods has been reported elsewhere [15]. This is a cross-sectional study conducted from 2008 to 2010 among 12,948 individuals representative of the non-institutionalized Spanish population aged 18 years and older. The study participants were selected by stratified cluster sampling. The sample was first stratified by province (the 50 provinces of Spain) and size of municipality (10,000; 10,000-100,000; 100,000-500,000; > 500,000 population). Second, clusters were selected randomly in 2 stages: municipalities and census sections. Finally, the households within each section were selected by random telephone dialing using the directory of telephone land-lines as the sampling frame. Subjects in the households were selected proportionally to the distribution of the population of Spain by sex and age group (18-29, 30-44, 45-64, ≥65 years). Only 1 person was selected in each household; when there was more than one person in the required age and sex group, the invited individual was chosen randomly. Information was obtained from a total of 248 municipalities and 1241 census sections in Spain.

Information was collected in three stages. First, a phone interview on socio-demographic, lifestyle and diagnosed morbidity; second, a home visit to obtain blood and urine samples; and third, another home visit to administer a structured questionnaire on OREB, to obtain a diet history and to measure blood pressure and anthropometric variables.

Study participants provided written informed consent. The ENRICA protocol was approved by the clinical research ethics committees of the University Hospital *La Paz* in Madrid and Hospital *Clinic* in Barcelona.

Study variables

Obesity-related eating behaviors

We used information on 8 self-reported OREB which have been shown to be associated with increased energy intake [5]. We asked participants the following question about planning the amount of food served on the plate: 1) “Before sitting down at the table, do you think about how much you intend to eat?” Other OREB considered were 2) consuming precooked and/or canned foods, 3) buying chocolates or other snacks in vending machines, and 4) eating in fast-food restaurants. Participants also reported whether they had any mindful eating behaviors such as 5) selecting low-energy foods, 6) removing visible fat from meat, and 7) taking the skin off the chicken before eating. To assess meal context, participants were asked 8) how often they had lunch or dinner while watching TV.

Diet

We used a computerized diet history, developed from the one used in the EPIC-cohort study in Spain [16, 17], to assess habitual food consumption the previous year. The diet history asked about the food consumed in a typical week, and all foods consumed at least once every 15 days were recorded. Nutrient intake was calculated using standard food composition tables [15]. The diet history collected detailed information on the daily EO, including the three main meals (breakfast, lunch and dinner) and the two intermediate meals (the mid-morning snack or "almuerzo," and the afternoon snack or "merienda"), which form part of the traditional Spanish diet. Eating between meals (snacking) was considered an additional EO, which in most cases took place after dinner. Thus the range of EO was 0 to 6. Food portion size per EO was obtained by summing the weight (g) of all solid foods consumed divided by the number of EO. Lastly, ED from solid food was calculated as the ratio of the total energy intake (kcal) from solid foods over the total weight of those foods in a week. Beverages were excluded from the calculations because energy intake from beverages is regulated differently from energy intake from solid foods and because ED from solid food has shown stronger associations with weight change than ED from all foods (solid plus liquid) [18].

The diet history also assessed the reported consumption of sugar-sweetened beverages (carbonated and non-carbonated drinks, iced drinks, energy drinks, fruit juices and nectars) and of alcoholic beverages (wine, beer, cider, spirits). Beverage consumption was expressed in ml/day.

Other variables

We also considered other variables which could be associated with OREB and with energy intake [19]. Individuals reported sociodemographic variables (sex, age, educational level, occupation-based social class) and lifestyles, including smoking, time spent watching TV and leisure time physical activity, which was assessed with the EPIC-Spain questionnaire and expressed as metabolic equivalent tasks (MET)-hour/week [20].

Weight and height were measured with standardized procedures [21], and we calculated body mass index (BMI) as weight in kg divided by squared height in m.

Information was also used on physician-diagnosed morbidity reported by the participant, including coronary disease, stroke, cancer at any site, and osteomuscular disease (osteoarthritis, rheumatoid arthritis, and hip fracture).

Statistical analysis

Among the 12,948 participants, we excluded 590 who lacked data on at least one OREB, 206 without diet information, 71 with extreme values on energy intake (<800 to >5000 kcal/day in men; <500 to >4000 kcal/day in women), and 535 without data on other study variables. Thus, the analyses were conducted with 11,546 individuals.

The association between each OREB and portion size, ED and number of EO of solid food, and consumption of sugary and alcoholic beverages was summarized with β coefficients and their 95% confidence intervals, obtained from linear regression. The analyses were also conducted with the number of OREB as the principal independent variable. To ensure a sufficient number of individuals, the OREB were grouped in five categories: ≤1, 2, 3, 4 and ≥5. We tested the linear relationship (P for trend) by modeling the number of OREB as a continuous variable. Regression models were adjusted for sociodemographic and lifestyle variables, BMI, and reported morbidity; moreover, they were adjusted simultaneously for portion size, ED, number of EO, and consumption of sugary and alcoholic drinks, because these variables are usually correlated (table 1).

Statistical significance was set at two-sided $p < 0.05$. Statistical analyses were performed with the survey procedures in Stata v.11, StataCorp LP, USA, to account for the complex sampling design [22].

RESULTS

Among the 11,546 study participants, the portion size (mean ± SD) of solid food was 289±94 g/EO, ED from solid food was 1.5±0.36 kcal/g and the number of EO per day was 4.7±1. Also, they consumed 114±220 ml/day of sugary drinks and 127±241 ml/day of alcoholic beverages.

Table 1 shows the matrix of correlations between the dependent variables in this study. As expected, the food portion size was inversely correlated with food ED and the number of EO. Moreover, food ED showed a direct correlation with the consumption of sugary and alcoholic beverages.

Table 2 shows that the portion size was higher in men and in those with higher physical activity. As regards ED, it was higher in men, younger individuals, and current smokers. Consumption of sugary and alcoholic beverages was higher in men, the youngest population segment, those with university studies, current smokers, and the most physically active. As also shown in table 2, individuals with obesity and reported morbidity generally had a larger portion size, lower ED and lower consumption of sugary drinks. Lastly, while obesity and stroke were associated with higher consumption of alcoholic beverages, coronary disease, asthma, cancer and osteomuscular disease were associated with lower consumption (table 2).

Eating precooked food and rarely removing visible fat from meat or skin from chicken were associated with higher portion size, while not planning the amount of food to eat was inversely associated (table 3). All OREB were associated with a slightly higher ED, with the exception of not planning the amount of food to eat, which showed an inverse association. Individuals who frequently ate precooked foods, bought snacks at vending machines and ate while watching TV showed a higher number of EO, but those who frequently ate at fast-food restaurants and who rarely chose low-energy foods had a lower number of EO (table 3).

As regards consumption of beverages, not planning the amount of food to eat, eating at fast-food restaurants and eating while watching TV were associated with higher intake of sugary drinks. Moreover, those who rarely chose low energy food had a higher consumption of alcoholic beverages (table 3).

An increasing number of OREB was associated with increasing ED from solid food, and with increasing consumption of sugary and alcoholic beverages (table 4). Compared to individuals with ≤1 OREB, those with ≥5 OREB had a higher ED (β 0.10; 95% CI 0.08, 0.12 kcal/g/day; p-trend <0.001) and a higher intake of sugary drinks (β 7; 95% CI -7, 20 ml/day; p-trend <0.05) and of alcoholic beverages (β 24; 95% CI 10, 38 ml/day; p-trend <0.001). No clear association was found between the number of OREB and food portion size or the number of EO.

To further understand the association between the number of OREB and ED, we calculated the Pearson correlation coefficients between ED and consumption of individual food groups. The types of food most positively associated with ED were sweets, bread, sausages, cheese and other dairy products, pasta and potatoes; the foods most inversely correlated were fresh fruits, vegetables, white fish, legumes, oily fish and white meat (table 5). The number of OREB was then regressed on the consumption of those foods most strongly associated (either positively or negatively) with ED. An increasing number of OREB was associated with an increasing consumption of cheese and other dairy products and red meat, and with a decreasing consumption of fresh fruits, oily fish and white meat (p-trend <0.05 in all cases but red meat) (table 6). We also examined the association between the number of OREB and consumption of the main types of sugary and alcoholic beverages. We found a positive dose-response relationship (p-trend <0.001) between the number of OREB and the consumption of sugar-sweetened soft drinks and beer (table 6).

Lastly, those individuals with ≥5 OREB compared those with ≤1 OREB had a higher BMI (β 0.45; 95% CI 0.12, 0.78 kg/m^2; p-trend <0.05). Also, those with ≥5 OREB ingested 248 kcal/day more than those with ≤1 OREB. Of this excess energy intake, 85.8% came from solid food, 5.2% from sugary drinks and 9.0% from alcoholic beverages.

DISCUSSION

Our results show that a higher number of OREB is associated with higher ED from solid food and higher consumption of sugary and alcoholic beverages. Specifically, OREB were associated with higher intake of cheese and other dairy, red meat, sugar-sweetened soft drinks and beer, and with lower consumption of fresh fruit, oily fish and white meat.

The ED from solid food in Spain was lower than in the US (2.05 kcal/g in 2003-2006) [6], probably because the Spanish diet continues to include a large amount of vegetables and fruit, which is characteristic of the Mediterranean dietary pattern [23]. As expected, portion size per EO was inversely associated with ED, so that portion size in Spain was higher than in the US [6]. Moreover, less than 1% of the Spanish population skips breakfast, and midmorning or afternoon snacks are quite frequent [19], so that the number of EO (meals plus eating between meals) in Spain was similar to that in the US, where it was 4.9 EO/day in 2003-2006 [6]. In fact, the larger number of EO seems to be the factor that has contributed most to the increase in energy intake underlying the obesity epidemic in the US from 1976 to 2006 [6]. Lastly, consumption of sugary drinks in Spain was similar to that in some Anglo-Saxon countries like the United Kingdom [24], but still lower than in the US [25, 26].

Some of the associations between OREB and the components of energy intake are quite intuitive For instance, frequently buying chocolates and other snacks in vending machines and eating at fast-food restaurants, and rarely choosing low-energy foods showed the strongest associations with higher ED from solid food. Also, as expected, eating at fast-food restaurants and eating while watching TV had the strongest association with higher consumption of sugary drinks. These observations provide additional biological plausibility to the relationship between OREB and excess weight because there is substantial evidence that increasing ED from solid food [18] and intake of sugary drinks [27, 28] is associated with weight gain.

Previous research has also found an association between several OREB, ED and consumption of sugary drinks. Specifically, in Spanish adults, frequent fast-food consumption has been linked to increased ED and energy intake [29]. Also, in US children and adults, the consumption of sugary drinks has been found to be higher in those who used vending machines and consumed fast-food [30, 31], and in those who frequently ate while watching TV [32, 34].

Although we found no clear association between the number of OREB and EO, a few OREB did show such an association. Specifically, eating precooked food, buying snacks in vending machines and eating while watching TV were associated with a higher number of EO. The relevance of these associations is uncertain, because eating frequency has not been consistently associated with obesity [35]. Nevertheless some of our results are in line with previous research, because eating while watching TV has been related to snacking, which may increase the number of EO [36].

Not choosing low-energy foods was the only OREB to be statistically associated with higher consumption of alcoholic drinks, but most of the other OREB also showed a tendency towards higher consumption. As a result, the number of OREB showed a dose-response relation with the consumption of alcoholic beverages. In previous research, alcohol intake has been linked with fast-food consumption [31] and with eating while watching TV [33, 34]. Of note is that, although alcohol intake has been linked to increased energy intake [37], and drinking alcohol with meals has been linked to poor adherence to dietary guidelines [38], the association between alcohol intake and obesity is still uncertain [39].

Given that the magnitude of the association between OREB and energy intake was small, the association between OREB and higher food ED and consumption of sugary and alcoholic drinks should necessarily be small. However, even small associations may suffice to alter energy balance and produce obesity in the long term [40]. In the Nurses' Health Study, an increase of 0.25 kcal/g in ED from solid food (about double the ED associated with ≥5 OREB in our study) was associated with a 5-kg gain over 8 years of follow-up [18]. As for sugary drinks, an increase of a 12-ounce serving (about 9 times the amount of sugary drinks associated with ≥5 OREB) was linked to a gain of 0.6 kg over 4 years in three separate US cohorts [27].

This work has several strengths and limitations. Among the strengths is the large study sample, which is representative of the population of an entire country. Also, diet was measured with a validated diet history. Lastly, the analyses controlled for a good number of confounders. The most important limitation is the cross-sectional design, which does not permit causal inferences for the observed associations. Another limitation was that, as in previous research in this field [35], we lacked standardized definitions of OREB and rigorously validated questionnaires to assess them; moreover OREB were self-reported, which may lead to underestimation of the true frequency of the OREB, because of recall or desirability bias. The most likely effect on the study results is underestimation of the true association between OREB and energy intake and its drivers (e.g., portion size, sugary drinks, etc.).

Lastly, our results are of practical importance because they support healthy-diet guidelines recommending to moderate OREB. Also, our results suggest possible ways to reduce excess energy intake associated with OREB. The first one is to augment consumption of low-ED food associated with lower weight gain, like fresh fruit or vegetables or soups; at the same time, to reduce high-ED food, like processed meat, and to substitute high-fat for low-fat dairy

[10]. The second one is to replace sugary drinks with non-caloric beverages, in particular water, and to a lesser extent with non-sweetened coffee or tea, low-fat milk, and artificially-sweetened beverages [41]. And the third way is to reduce alcohol intake, particularly in the form of beer because it is the most frequently consumed alcoholic beverage and the one most strongly associated with excess energy intake in our study. These changes in food and beverage consumption would reduce energy intake while maintaining or even improving overall diet quality.

FINANCIAL DISCLOSURE

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AUTHORS' CONTRIBUTIONS

MMP and FRA designed and conducted research; MMP, PGC and ELG analyzed data; MMP and FRA wrote the paper; All authors reviewed the manuscript for important intellectual content. FRA had primary responsibility for final content. All authors read and approved the final manuscript.

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Table 1. Pearson correlation coefficients between food portion size, energy density of food, number of eating occasions, and beverage consumption.

	Energy density of solid food, kcal/g	Eating occasions of solid food, n/day[a]	Sugary beverages, ml/day	Alcoholic beverages, ml/day
Portion size of solid food, g/EO	-0.22**	-0.51**	0.01	0.07**
Energy density of solid food, kcal/g		0.02	0.22**	0.11**
Eating occasions of solid food, n/day[a]			0.01	-0.08**
Sugary beverages				-0.01

**p<0.001; EO: Eating occasion

[a] Eating occasions are breakfast, mid-morning snack, lunch, afternoon snack, dinner, and eating between these meals (in most cases after dinner).

Table 2. Portion size, energy density, number of eating occasions, and consumption of sugary and alcoholic beverages, according to the characteristics of the study participants.[a]

	Portion size of solid food g/EO	Energy density of solid food kcal/g	Eating occasions of solid food[b] n/day	Sugary beverages ml/day	Alcoholic beverages ml/day
Sex					
Men	317 (98)	1.60 (0.34)	4.57 (1.01)	138 (241)	194 (288)
Women	262 (81)	1.47 (0.37)	4.82 (1.02)	91 (193)	62 (151)
Age, years					
18 – 44	282 (92)	1.64 (0.35)	4.74 (1.00)	165 (261)	119 (242)
45 – 64	299 (99)	1.48 (0.35)	4.70 (1.06)	75 (171)	153 (267)
≥ 65	291 (93)	1.36 (0.30)	4.61 (1.01)	44 (109)	110 (198)
Educational level					
Primary school or less	288 (92)	1.48 (0.35)	4.69 (1.01)	89 (190)	118 (235)
Secondary school	289 (94)	1.59 (0.36)	4.69 (1.03)	147 (256)	128 (251)
University	291 (98)	1.52 (0.35)	4.72 (1.03)	92 (186)	137 (234)
Smoking					
Never smokers	286 (92)	1.49 (0.35)	4.74 (1.02)	108 (208)	83 (167)
Past smokers	303 (98)	1.49 (0.35)	4.66 (1.03)	88 (187)	170 (270)
Current smokers	282 (93)	1.65 (0.35)	4.66 (1.03)	149 (261)	167 (302)
Social class					
Manual workers	291 (97)	1.52 (0.36)	4.66 (1.03)	104 (213)	127 (236)
Non-manual workers	287 (92)	1.56 (0.36)	4.75 (1.01)	127 (230)	128 (249)
Physical activity, METs-h/week					
Tertile 1 (<16.5)	283 (93)	1.56 (0.37)	4.67 (1.05)	109 (216)	122 (261)
Tertile 2 (≥16.5 to <33)	288 (95)	1.50 (0.36)	4.71 (1.03)	98 (118)	120 (218)
Tertile 3 (≥33)	295 (95)	1.55 (0.34)	4.72 (0.99)	134 (226)	139 (243)
Time spent watching TV, h/week					
Tertile 1 (<7)	292 (97)	1.55 (0.36)	4.73 (1.05)	118 (211)	123 (236)
Tertile 2 (≥7 to <14)	289 (91)	1.54 (0.36)	4.67 (1.02)	122 (242)	131 (244)
Tertile 3 (≥14)	288 (95)	1.52 (0.36)	4.70 (1.01)	108 (212)	127 (242)
Body mass index, kg/m^2					
<25	280 (92)	1.57 (0.36)	4.73 (1.01)	132 (240)	95 (194)
25-29.9	295 (97)	1.52 (0.35)	4.67 (1.04)	102 (195)	147 (257)
≥30	296 (93)	1.51 (0.37)	4.68 (1.01)	107 (227)	147 (275)
Coronary heart disease					
No	289 (94)	1.54 (0.36)	4.70 (1.02)	114 (221)	128 (242)
Yes	315 (107)	1.36 (0.32)	4.49 (0.97)	35 (65)	76 (169)
Stroke					
No	289 (94)	1.59 (0.36)	4.70 (1.02)	115 (221)	127 (241)
Yes	301 (98)	1.43 (0.31)	4.49 (0.98)	59 (97)	149 (271)
Asthma					
No	289 (94)	1.54 (0.36)	4.70 (1.03)	114 (221)	129 (245)
Yes	282 (96)	1.54 (0.35)	4.73 (0.97)	112 (209)	99 (190)
Cancer at any site					
No	289 (94)	1.54 (0.36)	4.70 (1.02)	115 (221)	128 (241)
Yes	293 (105)	1.44 (0.33)	4.73 (0.94)	61 (129)	97 (241)
Osteomuscular disease					
No	290 (95)	1.57 (0.36)	4.69 (1.03)	127 (232)	133 (248)
Yes	286 (93)	1.41 (0.34)	4.73 (1.01)	66 (159)	105 (213)

EO: Eating occasion; SD: Standard deviation

[a] Values are means (standard deviation).

[b] Eating occasions are breakfast, mid-morning snack, lunch, afternoon snacks, dinner and eating between these meals (in most cases after dinner).

Table 3. Association of individual obesity-related eating behaviors with portion size, energy density of foods, number of eating occasion, and beverage consumption[a] N= 11,546.

	Portion size of solid food, g/EO	Energy density of solid food, kcal/g	Eating occasions of solid food, n/day	Sugary beverages, ml/day	Alcoholic beverages, ml/day
Planning how much to eat before sitting down					
Yes	Ref.	Ref.	Ref.	Ref.	Ref.
No	-8 (-12, -5)**	-0.03 (-0.04, -0.01)*	0.02 (-0.03, 0.07)	16 (6, 25)*	3 (-8, 14)
Eating precooked/canned food					
< 1 time/wk	Ref.	Ref.	Ref.	Ref.	Ref.
≥ 1 time/wk	6 (3, 9)*	0.05 (0.03, 0.06)**	0.27 (0.23, 0.30)**	5 (-5, 14)	10 (-9, 20)
Buying snacks at vending machines					
< 1 time/wk	Ref.	Ref.	Ref.	Ref.	Ref.
≥ 1 time/wk	-3 (-11, 4)	0.10 (0.07, 0.14)**	0.18 (0.09, 0.26)**	10 (-14, 35)	-10 (-39, 18)
Eating at fast-food restaurants					
< 1 time/wk	Ref.	Ref.	Ref.	Ref.	Ref.
≥ 1 time/wk	-3 (-9, 3)	0.11 (0.08, 0.13)**	-0.09 (-0.15, -0.02)*	69 (45, 91)**	-21 (-46, 3)
Choosing low-energy foods					
Frequently/always/sometimes	Ref.	Ref.	Ref.	Ref.	Ref.
Never/almost never	3 (-0.35, 7)	0.10 (0.09, 0.12)**	-0.10 (-0.14, -0.06)**	6 (-5, 16)	20 (9, 31)**
Removing visible fat from meat[b]					
Frequently/always/sometimes	Ref.	Ref.	Ref.	Ref.	Ref.
Never/almost never	7 (1, 13)*	0.06 (0.04, 0.08)**	-0.03 (-0.09, 0.02)	12 (-4, 28)	11 (-6, 28)
Removing skin from chicken[c]					
Frequently/always/sometimes	Ref.	Ref.	Ref.	Ref.	Ref.
Never/almost never	5 (0.22, 10)*	0.06 (0.04, 0.08)**	0.02 (-0.03, 0.07)	6 (-10, 24)	15 (-2, 32)
Eating while watching TV					
≤ 2 times/wk	Ref.	Ref.	Ref.	Ref.	Ref.
> 2 times/wk	2 (-2, 6)	0.04 (0.02, 0.05)**	0.05 (0.01, 0.09)*	19 (10, 29)**	4 (-8, 15)

*p<0.05; **p<0.001; EO: Eating occasion.

[a] Values are β (95% CI) obtained from linear regression and adjusted for sex, age, educational level, smoking, social class, leisure time physical activity, time spent watching TV, body mass index (<25, 25-29.9, ≥30 kg/m^2), coronary disease, stroke, asthma, cancer, osteomuscular disease, portion size of solid food, energy density of solid food, number of EO of solid food, consumption of sugary beverages, and consumption of alcoholic beverages, when appropriate.

[b] Analyses based on 10,154 participants who eat meat.

[c] Analyses based on 9,808 participants who eat chicken.

Table 4. Association of the number of obesity-related eating behaviors with portion size, energy density of foods, number of eating occasions, and beverage consumption. N= 11,546.

	Number of obesity-related eating behaviors[a]					
	≤1 (n=1,621)	**2 (n=2,314)**	**3 (n=2,439)**	**4 (n=1,578)**	**≥5 (n=3,594)**	**P-trend**
Portion size of solid food, *g/EO ,mean (SD)*	289 (94)	292 (96)	291 (93)	293 (95)	285 (94)	
β (95% CI)[b]	Ref.	2 (-4, 7)	3 (-2, 8)	1 (-5, 6)	4 (-1, 10)	0.138
Energy density of solid food, *kcal/g , mean (SD)*	1.43 (0.34)	1.47 (0.35)	1.55 (0.34)	1.58 (0.36)	1.60 (0.36)	
β (95% CI)[b]	Ref.	0.01 (-0.01, 0.03)	0.07 (0.05, 0.09)**	0.08 (0.05, 0.10)**	0.10 (0.08, 0.12)**	<0.001
Eating occasions of solid food, *n/day, mean (SD)*	4.73 (1.06)	4.66 (1.01)	4.65 (1.00)	4.60 (1.02)	4.78 (1.02)	
β (95% CI)[b]	Ref.	-0.04 (-0.10, 0.02)	-0.03 (-0.10, 0.03)	-0.09 (-0.16, -0.02)*	0.07 (0.01, 0.13)*	0.008
Sugary beverages, *ml/day, mean (SD)*	89 (200)	97 (201)	107 (224)	138 (255)	131 (219)	
β (95% CI)[b]	Ref.	-4 (-18, 9)	-7 (-22, 7)	15 (-3, 33)	7 (-7, 20)	<0.05
Alcoholic beverages, *ml/day, mean (SD)*	102 (193)	110 (22)	132 (250)	136 (258)	143 (253)	
β (95% CI)[b]	Ref.	4 (-10, 17)	16 (2, 30)*	9 (-9, 26)	24 (10, 38)*	<0.001

*p<0.05; **p<0.001; EO: Eating occasion; SD: Standard deviation

[a] Obesity-related eating behaviors are as follows: not planning how much to eat before sitting down, consuming precooked and/or canned foods ≥1 time/wk, buying snacks at vending machines ≥1 time/wk, eating at fast-food restaurants ≥1 time/wk, never or almost never choosing low-energy foods, never or almost never removing visible fat from meat, never or almost never removing skin from chicken, and eating while watching TV >2 times/wk.

[b] Adjusted for sex, age, educational level, smoking, social class, leisure time physical activity, time spent watching TV, body mass index (<25, 25-29.9, ≥30 kg/m^2), coronary disease, stroke, asthma, cancer, osteomuscular disease, portion size of solid food, energy density of solid food, number of EO of solid food, consumption of sugary beverages, and consumption of alcoholic beverages, when appropriate.

Table 5. Top positive and negative Pearson correlations coefficients between food groups and total energy density from solid food. [a] N= 11,546

Positive			Negative		
Rank	**Food group**	**Pearson correlation coefficient**	**Rank**	**Food group**	**Pearson correlation coefficient**
1	Sweets [b]	0.48	**1**	Fresh fruits [i]	-0.56
2	Bread [c]	0.30	**2**	Vegetables [j]	-0.45
3	Sausages [d]	0.29	**3**	White fish [k]	-0.14
4	Cheese and other dairy products [e]	0.16	**4**	Legumes [l]	-0.10
5	Pasta [f]	0.16	**5**	Oily fish [m]	-0.08
6	Potatoes [g]	0.13	**6**	White meat [n]	-006
7	Red meat [h]	0.09			

[a] Results are shown only for food groups with Pearson correlation coefficient >0.05.
[b] Jam, chocolate pudding, chocolate truffles, chocolate-hazelnut creams, nougats, marzipan, cakes, sponge cakes, croissants, donuts, pastries and cookies.
[c] White bread, wholemeal bread, breadsticks, hamburger and hotdog buns.
[d] Pork sausages, veal sausages, and poultry sausages.
[e] Unripened cheese, ripened cheese, processed cheese, yogurt, custard, mousse, and ice cream.
[f] Unstuffed pasta, stuffed pasta, and pizza.
[g] Baked potatoes, boiled potatoes, mashed potatoes, French fries, and potato chips.
[h] Veal, beef, pork, wild boar, horse, lamb and goat..
i Berries, custard apple, apple, pear, plum, pomegranate, passion fruit, fig, kiwi, lychee, lime, lemon, tangerine, orange, mango, peach, nectarine, apricot, loquat, persimmon, watermelon, papaya, and pineapple.
j Chard, celery, watercress, collard green, borage, spinach, cabbage, endive, lettuce, thistle, scallion, fennel, onion, leek, garlic, asparagus, palm heart, turnip, parsnip, radishes, beets, soy, carrot, artichoke, eggplant, broccoli, cauliflower, zucchini, pumpkin, green been, corn, pepper, tomato, champignon, and mushroom.
[k] Pollack, weever, blue whiting, cod, sea bream, red scorpionfish, dogfish, black seabream, pouting, megrim, halibut, common sole, seabass, whiting, hake, grouper, flathead mullet, common pandora, young hake, catshark, plaice, angler, blonde ray, turbot, red mullet, and white seabream.
[l] Chickpeas, beans, and lentils.
[m] Anchovy, sardine, eel, herring, tuna, albacore, Atlantic horse mackerel, Atlantic mackerel, transparent goby, conger, swordfish, pomfret, and salmon.
[n] Chicken, quail, pheasant, goose, duck, turkey, pigeon, partridge and rabbit.

Table 6. Association of the number of obesity-related eating behaviors with individual foods groups associated with energy density (ED) and with the main type of sugary and alcoholic beverages. N= 11,546

	Number of obesity-related eating behaviors[a]					
	≤1 (n=1,621)	2 (n=2,314)	3 (n=2,439)	4 (n=1,578)	≥5 (n=3,594)	P-trend
Foods groups associated with higher ED						
Sweets, *g/day ,mean (SD)*	52 (60)	54 (62)	58 (60)	60 (69)	65 (62)	
β (95% CI)[b]	Ref.	0.54 (-3.13, 4.21)	-2.51 (-6.39, 1.36)	-1.30 (-5.70, 3.11)	0.34 (-3.28, 3.96)	0.922
Bread, *g/day ,mean (SD)*	148 (90)	153 (88)	160 (90)	157 (92)	166 (95)	
β (95% CI)[b]	Ref.	2.35 (-3.24, 7.94)	1.71 (-4.20, 7.61)	-4.06 (-10.72, 2.59)	2.79 (-3.09, 8.69)	0.771
Sausages, *g/day ,mean (SD)*	43 (54)	45 (52)	50 (52)	55 (60)	50 (53)	
β (95% CI)[b]	Ref.	-0.32 (-3.80, 3.73)	0.91 (-3.09, 4.91)	3.29 (-1.39, 7.97)	-2.38 (-5.86, 1.09)	0.211
Cheese and other dairy, *g/day ,mean (SD)*	65 (79)	69 (75)	75 (80)	77 (82)	85 (80)	
β (95% CI)[b]	Ref.	4.26 (-0.93, 9.44)	6.12 (1.01, 11.21)*	6.77 (0.60, 12.93)*	12.7 (7.62, 17.85)**	<0.001
Pasta, *g/day ,mean (SD)*	38 (35)	42 (39)	46 (39)	50 (46)	48 (40)	
β (95% CI)[b]	Ref.	1.91 (-0.48, 4.31)	2.91 (0.57, 5.27)*	5.18 (1.89, 8.46)*	2.22 (-0.12, 4.57)	0.092
Potatoes, *g/day ,mean (SD)*	48 (43)	48 (40)	49 (41)	51 (42)	48 (36)	
β (95% CI)[b]	Ref.	-1.22 (-3.95, 1.51)	-1.80 (-4.74, 1.13)	-0.36 (-3.62, 2.91)	-4.65 (-7.33, -1.97)*	<0.001
Red meat, *g/day ,mean (SD)*	29 (33)	32 (34)	34 (37)	37 (40)	34 (35)	
β (95% CI)[b]	Ref.	2.70 (0.61, 4.78)*	4.05 (1.80, 6.30)**	4.83 (2.11, 7.55)**	2.36 (0.25, 4.48)*	0.130
Foods groups associated with lower ED density						
Fresh fruits, *g/day ,mean (SD)*	278 (198)	257 (185)	225 (175)	204 (173)	214 (169)	
β (95% CI)[b]	Ref.	-0.75 (-11.30, 9.81)	-7.75 (-18.03, 2.53)	-16.68 (-28.51, -4.82)*	-8.76 (-18.78, 1.26)	0.014
Vegetables, *g/day ,mean (SD)*	218 (140)	210 (148)	198 (129)	196 (133)	190 (122)	
β (95% CI)[b]	Ref.	-1.58 (-10.3, 7.21)	0.53 (-7.84, 8.90)	0.41 (-8.92, 9.74)	-3.68 (-11.55, 4.19)	0.389
White fish, *g/day ,mean (SD)*	28 (36)	27 (32)	25 (43)	24 (30)	25 (28)	
β (95% CI)[b]	Ref.	-0.64 (-3.02, 1.75)	-1.17 (-3.75, 1.41)	-1.28 (-3.83, 1.27)	-0.96 (-3.28, 1.35)	0.433
Legumes, *g/day ,mean (SD)*	57 (71)	54 (63)	54 (61)	52 (57)	54 (58)	
β (95% CI)[b]	Ref.	-2.13 (-6.68, 2.41)	-0.55 (-5.48, 4.38)	-2.60 (-7.67, 2.47)	-1.39 (-5.76, 2.99)	0.680
Oily fish, *g/day ,mean (SD)*	19 (27)	19 (26)	17 (23)	18 (23)	17 (20)	
β (95% CI)[b]	Ref.	0.08 (-1.58, 1.74)	-1.17 (-2.80, 0.46)	-0.54 (-2.39, 1.30)	-2.00 (-3.55, -0.46)*	0.002
White meat, *g/day ,mean (SD)*	39 (36)	42 (41)	42 (40)	42 (37)	35 (35)	
β (95% CI)[b]	Ref.	2.65 (0.05, 5.24)*	2.47 (-0.19, 5.13)	1.64 (-1.11, 4.40)	-4.03 (-6.54, -1.52)*	<0.001

Table 6. Cont.

	Number of obesity-related eating behaviors[a]					
	≤1 (n=1,621)	**2 (n=2,314)**	**3 (n=2,439)**	**4 (n=1,578)**	**≥5 (n=3,594)**	**P-trend**
Sugary beverages						
Sugar-sweetened soft drinks, *ml/day, mean(SD)*	56 (161)	63 (166)	76 (194)	97 (217)	94 (194)	
β (95% CI)[b]	Ref.	-2 (-14, 9)	-2 (-14, 11)	13 (-3, 28)	11 (-1, 22)	<0.001
Juices and nectars, *ml/day, mean (SD)*	33 (114)	33 (99)	32 (99)	42 (118)	36 (96)	
β (95% CI)[b]	Ref.	2 (-9, 6)	-6 (-14, 2)	2 (-7, 11)	-4 (-11, 3)	0.482
Alcoholic beverages						
Beer, *ml/day, mean (SD)*	41 (128)	52 (162)	77 (205)	75 (205)	90 (217)	
β (95% CI)[b]	Ref.	6 (-4, 16)	22 (11, 34)**	12 (-2, 25)	31 (20, 42)**	<0.001
Wine, *ml/day, mean (SD)*	59 (133)	53 (139)	50 (126)	54 (139)	48 (112)	
β (95% CI)[b]	Ref.	-4 (-12, 5)	-7 (-16, 1)	-5 (-16, 5)	-8 (-16, -1)	0.053
Spirits, *ml/day, mean (SD)*	2 (13)	4 (15)	4 (17)	7 (25)	5 (18)	
β (95% CI)[b]	Ref.	1 (-0.14, 2)	1 (-1, 2)	2 (1, 4)*	1 (-0.01, 2)	0.043

*p<0.05; **p<0.001; EO: Eating occasion; SD: Standard deviation

[a] Obesity-related eating behaviors are as follows: not planning how much to eat before sitting down, consuming precooked and/or canned foods ≥1 time/wk, buying snacks at vending machines ≥1 time/wk, eating at fast-food restaurants ≥1 time/wk, never or almost never choosing low-energy foods, never or almost never removing visible fat from meat, never or almost never removing skin from chicken, and eating while watching TV >2 times/wk.

[b] Adjusted for sex, age, educational level, smoking, social class, leisure time physical activity, time spent watching TV, body mass index (<25, 25-29.9, ≥30 kg/m^2), coronary disease, stroke, asthma, cancer, osteomuscular disease, portion size of solid food, energy density of solid food, number of EO of solid food, consumption of sugary beverages, and consumption of alcoholic beverages, when appropriate.

9. DISCUSIÓN

En la revisión sistemática de la literatura se observó que tanto en niños como en adultos las evidencias sobre la relación entre las conductas alimentarias y la obesidad son escasas o inconsistentes. En dos estudios, en los análisis transversales la menor frecuencia del desayuno se asoció con el exceso de peso corporal. Esto podría deberse a que los obesos se saltan el desayuno para controlar el peso. Sin embargo, esto no fue observado en análisis longitudinales de estas investigaciones (Berkey et al. 2003; Timlin et al., 2008). Asimismo, desayunar podría proteger del exceso de peso (Van der Heijden et al., 2007; Goto et al., 2010), pero es difícil distinguir el efecto de desayunar del efecto del contenido del desayuno. Por otro lado, aunque clásicamente la mayor frecuencia de comidas se ha asociado con una menor frecuencia de obesidad, en nuestra revisión no se encontró suficiente evidencia de ello. Por un lado, había heterogeneidad en la definición de las comidas, y por otro un predominio de estudios transversales con limitada capacidad para demostrar causalidad. Tampoco se encontraron evidencias claras de una asociación entre snacking y exceso de peso, especialmente en niños y adolescentes. Ello también puede deberse a las diferentes definiciones de snacking usadas y al uso de diseños transversales en varios estudios. En cambio en adultos existen estudios longitudinales donde se observó una mayor frecuencia de obesidad en los que consumían snacks varias veces al día (Chapelot, 2011). Por otra parte, a diferencia de lo esperado, en esta revisión sólo unos pocos estudios longitudinales en niños (Taveras et al., 2005; Niemeier et al., 2006) y adultos (Pereira et al., 2005; Bes-Rastrollo et al., 2006; Duffey et al., 2007) mostraron que la comida rápida se asocia a exceso de peso. Por último, tampoco se encontraron estudios longitudinales sobre la influencia en el peso corporal del consumo irregular de las comidas, comer hasta estar satisfecho (en niños) y comer rápido (en adultos). En conjunto, la escasa evidencia disponible sobre estos tres comportamientos alimentarios no permite concluir si son relevantes para la producción de obesidad.

Por otro lado, nuestros resultados, en datos del estudio ENRICA, mostraron que las conductas alimentarias relacionadas con la obesidad se asocian a una mayor ingesta de alimentos sólidos con elevada densidad energética y a un mayor consumo de bebidas azucaradas y alcohólicas. Estos resultados explican los mecanismos por los cuales las conductas alimentarias se asocian a una mayor ingesta energética, algunos de los cuales son bastantes intuitivos. Por ejemplo, comprar chocolatinas o algún otro snacks en máquinas expendedoras, o comer en restaurantes de comida rápida, o rara vez escoger alimentos bajos en caloría muestra una fuerte asociación con el consumo de alimentos de elevada densidad energética. Asimismo, comer en restaurantes de comida rápida y comer mientras se ve TV se asociaron con un alto consumo de bebidas azucaradas. Estas observaciones entregan plausibilidad biológica a la relación entre las conductas alimentarias y el exceso de peso, ya que existe evidencia substancial de que el consumo de alimentos sólidos con elevada densidad energética (Bes-Rastrollo et al., 2008) y la ingesta de bebidas azucaradas (Brown et al., 2008; Mozaffarian et al., 2011) se asocian con la ganancia de peso. Por otro lado, estudios previos también han encontrado asociación entre algunas conductas alimentarias, la densidad energética y el consumo de bebidas azucaradas. En España, específicamente, el consumo frecuente de comida rápida se ha vinculado a una elevada densidad energética e ingesta energética (Schröder et al. 2007). Además, en niños y adultos americanos, el consumo de bebidas azucaradas fue elevado entre aquellos que utilizan máquinas expendedoras y consumen comida rápida, y entre aquellos que frecuentemente comen viendo televisión (Wiecha et al., 2006; Paeratakul et al., 2003; Feldman et al., 2007; Rey-López et al., 2011). Asimismo el consumo de comida rápida (Paeratakul et al., 2003) y comer viendo televisión se vincularon a la ingesta de bebidas alcohólicas (Cleland et al., 2008; Rey-López et al., 2011).

La importancia práctica de nuestros resultados es que apoyan pautas de dieta saludable que se recomiendan para moderar algunas conductas alimentarias relacionadas con la obesidad. Además, nuestros resultados sugieren posibles formas de reducir el exceso de ingesta de energía asociada con estas conductas alimentarias. Lo primero es aumentar el consumo de alimentos bajos en densidad energética como la fruta fresca, vegetales o sopas; reducir los alimentos con elevada densidad energética como carnes procesadas y reemplazar los productos lácteos enteros por aquellos que son desnatados (Rolls et al., 2010). Lo segundo es reemplazar las bebidas azucaradas por aquellas sin calorías. Y tercero, reducir la ingesta de alcohol, particularmente el proveniente de la cerveza. Estos cambios podrían ayudar a disminuir la ingesta energética e incluso a mejorar la calidad de la dieta.

En investigaciones futuras sobre las conductas alimentarias se deberían considerar los siguientes aspectos: utilizar definiciones estandarizadas de las conductas alimentarias, medición de ellas con cuestionarios validados, ajustar los análisis por variables socioeconómicas, estilos de vida y dieta. Asimismo, se deben priorizar los estudios longitudinales y los ensayos clínicos a corto plazo. Finalmente, se debe tener en cuenta la variabilidad transcultural de las conductas alimentarias.

Por otra parte, respecto a las terapias nutricionales nuestros resultados mostraron que sólo la mitad de los Españoles con diabetes tenían una dieta acorde a las recomendaciones de la EASD, ADA y dieta Mediterránea. Más aún, la ausencia de diferencias dietéticas entre individuos diagnosticados y no diagnosticados sugiere deficiencias del sistema de salud en el manejo de la diabetes.

La dieta de los diabéticos en España es consistente con la llamada “dieta mediterránea evolucionada”, que es la dieta de la población española hoy en día (García-Closas et al., 2006; Varela-Moreiras et al., 2010; Guallar-Castillón et al, 2012). Esta dieta mantiene la ingesta considerable del aceite de oliva, alimentos a base de verduras y la ingesta moderada de pescado, típico de la dieta mediterránea, pero ha incorporado el consumo de alimentos ricos con grasas saturadas y colesterol, y alimentos ricos en azúcar, características propias de la dieta occidental.

Entre los diabéticos, el acuerdo con las principales recomendaciones nutricionales aumenta con la edad. Esto es consistente con lo observado en estudios realizados en la población general Española, la cual ha encontrado que los adultos mayores tienen un mejor cumplimiento de los objetivos nutricionales y una mayor adherencia a la dieta mediterránea (Tur et al., 2004; Serra-Majem et al, 2007). Esto se debe, principalmente a razones culturales, y a que es más fácil para las personas mayores cocinar y comer en casa.

Respecto a la ingesta de sodio, grasas saturadas y azúcares añadidos en hipertensos y diabéticos Españoles, se observó que sólo unos algunos alimentos representan una parte sustancial del consumo elevado de ellos. Es más, algunos de esos alimentos son fuentes importantes para más de un nutriente, en particular los embutidos curados contribuyen a la ingesta excesiva de sodio y grasas saturadas, mientras que la bollería es una de las fuentes principales de grasas saturadas y azúcares añadidos.

La mitad de la ingesta de sodio provino del pan y los embutidos. Aunque el pan no es muy rico en sodio, su elevado consumo en hipertensos (160 g/día) y diabéticos (164 g/día) lo convierte en una de las fuentes principales de este nutriente. El Ministerio de Salud de España ha acordado recientemente con el sector empresarial una reducción gradual del 10% de sodio en el pan y embutidos (http://www.naos.aesan.mspsi.es/naos/empresas/compromisos/). Esto es importante porque puede ayudar a mejorar la dieta sin requerir cambios en el comportamiento de los pacientes.

El queso curado y a leche entera aportaron cerca del 20% de grasas saturadas en hipertensos y diabéticos, las siguientes fuentes más importantes fueron las carnes rojas y los embutidos. Es posible reducir la ingesta de este nutriente priorizando el consumo de quesos bajos en grasa o leches desnatadas o semidesnatadas. En cuanto a los azúcares añadidos, la fuente principal fue el azúcar añadido directamente a las bebidas, la bollería y los refrescos azucarados.

Nuestros resultados muestran deficiencias en las estrategias de nutrición de salud pública en España; no obstante, el Ministerio de Salud recientemente ha acordado con los productores de carne una reducción del 5% de grasas saturadas en las carnes procesadas (http://www.health.gov/dietaryguidelines/). Por otra parte, dado que las recomendaciones nutricionales para el tratamiento de la diabetes enfatiza en el bajo consumo de bollería y azúcar (Bantle et al., 2008; León-Muñoz et al., 2012)), nuestro estudio apunta a serias deficiencias en la terapia nutricional de pacientes diabéticos dentro del sistema de salud. Afortunadamente, la dieta de hipertensos y diabéticos puede mejorar con cambios sencillos, como disminuir el consumo de bollería y carne procesada, añadir edulcorantes en vez de azúcar al café u otras bebidas, y reemplazar las bebidas azucaradas por no azucaradas o agua.

Nuestros trabajos tuvieron algunas fortalezas y limitaciones metodológicas comunes. Entre las fortalezas de estos estudios se encuentran: la muestra, la cual es representativa de un país entero, siendo ENRICA el primer estudio poblacional nacional realizado en España. Y el uso de un instrumento validado (historia dietética) para medir la dieta. Entre las limitaciones está el diseño transversal, que no permite inferir causalidad de algunas de las asociaciones encontradas, y que las conductas alimentarias fueron autoreportadas, por lo que los resultados podrían haber estado sujetos al sesgo del recuerdo, o a la tendencia natural de los individuos a reportar comportamientos alimentarios aceptados socialmente.

10. CONCLUSIONES

En relación a las conductas alimentarias:

- **Conclusión objetivo 1**

A pesar que la dieta está obviamente vinculada con la obesidad, esta revisión sistemática y exhaustiva de la literatura ha demostrado que la evidencia sobre la relación entre las conductas alimentarias y la obesidad aún es escasa e inconsistente, tanto en niños como en adultos. Dado que las definiciones de las conductas alimentarias variaron según los artículos revisados, se hace necesario un enfoque más sistemático que permita captar los efectos de las conductas alimentarias en el control de peso.

- **Conclusión objetivo 2**

Un mayor número de conductas alimentarias relacionadas con la obesidad se asocia a la ingesta de alimentos sólidos con elevada densidad energética, y a un mayor consumo de bebidas azucaradas y alcohólicas. Específicamente las conductas alimentarias se asociaron con una mayor ingesta de quesos y otros lácteos, carnes rojas, refrescos azucarados y cervezas, y con un bajo consumo de fruta fresca, pescados azules y carnes blancas. No se encontró asociación entre el número de conductas alimentarias y el tamaño de la ración consumida o el número de ocasiones de ingesta.

En relación a las terapias nutricionales:

- **Conclusión objetivo 3**

Sólo alrededor de la mitad de los españoles con diabetes tiene una dieta acorde con las recomendaciones dietéticas de la EASD, ADA y dieta mediterránea. Es más, la falta de diferencias entre la dieta de los diabéticos diagnosticados y los no diagnosticados sugiere deficiencias del sistema sanitario en las intervenciones nutricionales frente a la diabetes mellitus.

- **Conclusión objetivo 4**

Unos pocos alimentos contribuyen de forma sustancial a la ingesta excesiva de sodio, grasas saturadas y azúcares añadidos en las personas con hipertensión y diabetes en España. Es más, algunos de los estos alimentos son fuentes importantes de más de un nutriente, en particular los embutidos crudos-curados contribuyen a la ingesta excesiva de sodio y grasas saturadas, mientras que la bollería es una de las principales fuentes de grasas saturadas y azúcares añadidos. En consecuencia, unos simples cambios en la dieta podrían traducirse en una mejora importante de la calidad nutricional de la dieta de estas personas.

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12. ANEXOS

12.1 Material suplementario Artículo 1 "Selected eating behaviours and excess body weight: a systematic review" (This document is available as Supplemental Material for inclusion as online documentation).

SUPPORTING INFORMATION

Eating behaviors and excess body weight: a systematic review

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Index of supporting information:

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Table S1. Bibliographic search history in PubMed (12/31/2010)

Search	Most Recent Queries	Result
#7	Search #6 AND (humans[mesh] and (clinical trial[ptyp] or meta-analysis[ptyp] or randomized controlled trial[ptyp] or review[ptyp] or case reports[ptyp] or clinical trial, phase iv[ptyp] or comparative study[ptyp] or controlled clinical trial[ptyp] or evaluation studies[ptyp] or journal article[ptyp] or multicenter study[ptyp] or overall[ptyp]))	5200
#6	Search #1 AND (#2 OR #3 OR #4 OR #5)	6450
#5	Search (snack*[title/abstract] or nibbling[title/abstract] or (meal frequency[title/abstract]) or (food frequency[title/abstract]) or (portion size[title/abstract]) or (meal size[title/abstract]) or (fast food[title/abstract]) or (irregular meal*[title/abstract]))	10530
#4	Search ((skip*[title/abstract] or consumption[title/abstract]) and (breakfast[title/abstract] or lunch[title/abstract] or dinner[title/abstract] or meal*[title/abstract]))	5003
#3	Search ((food[title/abstract] or meal*[title/abstract] or eating[title/abstract]) and (fast[title/abstract] or takeaway[title/abstract] or (away from home[title/abstract])))	4716
#2	Search ((eating habit*[title/abstract]) or (eating pattern*[title/abstract]) or (eating behavio*[title/abstract]) or (dietary habit*[title/abstract]) or (dietary pattern*[title/abstract]) or (feeding behavio*[title/abstract]) or (alimentary habit*[title/abstract]))	18342
#1	Search (obesity[title/abstract] or obese[title/abstract] or (metabolic syndrome[title/abstract]) or (syndrome x[title/abstract]) or (weight gain[title/abstract]) or (weight change[title/abstract]) or overweight[title/abstract] or fatness[title/abstract])	170705

Table S2. Associations between skipping breakfast, lunch or dinner and excess weight and metabolic syndrome, by study design and population.

Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Skipping breakfast, lunch or dinner: Cross-sectional studies in children and/or adolescents				
Amin et al. (2008)(23)	Eating breakfast was associated with lower frequency of overweight/obesity (OR 0.54; 95% CI 0.33-0.89) compared with not eating breakfast.	Age, maternal education, maternal occupational status, family size, consumption of food away from home, residence.	Y	+
Andersen et al (2005)(25)	Skipping breakfast 2-4 times/week (OR 1.99; 95% CI 1.25-3.18) and skipping breakfast ≥5 times/week (OR 1.69; 95% CI 0.99-2.89) were associated with overweight compared with skipping breakfast <2 times/week.	Age, sex, social class, energy intake, watching television and/or using computer, sweets intake.	Y	+++
Bibiloni et al. (2010)(39)	Eating breakfast 'always' or 'occasionally' did not show a statistically significant association with obesity in boys (OR 0.50, 95% CI 0.22-1.17; OR 0.68, 95% CI 0.25-1.85, respectively) and in girls (OR 0.56, 95% CI 0.26-1.20; OR 1.19, 95% CI 0.53-2.69, respectively) compared with 'always' skipping breakfast.	Crude analysis.	N	0
Bin Zaal et al. (2009)(40)	Eating breakfast always did not reach a statistically significant association with obesity in boys (OR 0.6; 95% CI 0.3-1.4) but it was associated with lower frequency of obesity in girls (OR 0.5; 95% CI 0.2-1.0) compared with never eating breakfast.	Crude analysis.	Sex interaction	0
Boutelle et al. (2002)(44)	Eating breakfast was associated with lower frequency of overweight in boys (OR 0.72; 95% CI 0.60-0.86) and tended to show a lower frequency of overweight in girls (OR 0.87; 95% CI 0.70-1.07) compared with not eating breakfast. Eating breakfast was associated with lower frequency of obesity both in boys (OR 0.68; 95% CI 0.54-0.86) and in girls (OR 0.72; 95% CI 0.53-0.97) compared with not eating breakfast	Race, parent socioeconomic level, grade.	Y	+
Bralic et al. (2005)(46)	Skipping breakfast was associated with higher BMI compared with breakfast consumption (21.0 ± 2.4 kg/m^2, 20.1 ± 1.9 kg/m^2, respectively). Skipping <u>dinner</u> was associated with higher BMI compared with dinner consumption (21.1 ± 2.3 kg/m^2, 19.6 ± 1.7 kg/m^2, respectively). Skipping <u>lunch</u> was not associated with BMI ($p>0.05$).	Crude analysis.	Y Y Y	0 0 0
Croezen et al. (2009)(52)	Skipping breakfast >2 days/week was associated with overweight in the groups with mean age of 13.4 years (OR 1.68; 95% CI 1.43-1.97) and with mean age of 15.5 years (OR 1.32; 95% CI 1.14-1.54) compared with never skipping breakfast.	Sex, education, physical inactivity, family situation, ethnic background, smoking, alcohol intake.	Y	++
de Gouw et al. (2010)(53)	In adolescents aged 10 to 14y, skipping <u>breakfast</u> was associated with overweight and obesity in boys (OR 1.33; 95% CI 1.04-1.70) but not in girls (OR 1.24; 95% CI 0.97-1.58). In those aged 15 to 18y, skipping breakfast was not associated with overweight and obesity in boys (OR 1.31; 95% CI 0.95-1.79) and in girls (OR 1.17; 95% CI 0.89-1.53). In adolescents aged 10 to 14y, skipping <u>lunch</u> was not associated with overweight and obesity in boys (OR 0.98; 95% CI 0.74-1.30) and in girls (OR 1.08; 95% CI 0.81-1.44). In those aged 15 to 18y, skipping lunch was associated with overweight and obesity in boys (OR 1.65; 95% CI 1.18-2.30) and in girls (OR 1.49; 95% CI 1.13-1.97).	Age, parents' education, school, birth weight, breast-feeding, puberty, parents' BMI, number of inhabitants, family size.	Age interaction	+

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Skipping breakfast, lunch or dinner: <u>Cross-sectional</u> studies in <u>children and/or adolescents</u> (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Deshmukh-Taskar et al. (2010)(54)	Skipping breakfast was associated with higher BMI ($p<0.05$) and obesity ($p<0.05$) compared with breakfast eating.	Age, ethnicity, poverty income ratio, physical activity, energy intake.	Y	+++
Dialektakou et al. (2008)(55)	Skipping breakfast (always) did not show a statistically significant association with overweight/obesity (OR 1.70; 95% CI 0.94-3.08) or with differences in BMI (p=0.292) compared with eating breakfast ≥1 day/week (on average). Skipping breakfast at the day of the interview was associated with overweight/obesity (OR 1.56, 95% CI 1.10-2.21) and with higher BMI ((β 0.69 ±0.32 kg/m^2; p=0.031) compared with breakfast eating at this day.	Age, sex, ethnicity, parental education, physical activity, smoking, dieting.	I	+++
Dubois et al. (2006)(56)	Skipping breakfast every day was associated with overweight (OR 1.9; 95% CI 1.2-3.2) compared with eating breakfast every day.	Sex, mother's education, household annual income, mother's immigrant status, number of overweight/obese parents.	Y	+
Dubois et al. (2009)(57)	Skipping breakfast every day was associated with overweight (OR 2.50; 95% CI 1.45-4.31) compared with eating breakfast every day.	Sex, mother's education, household annual income, mother's immigrant status, number of overweight/obese parents, birth weight, mother's smoking status, inactivity index, energy intake and intake of vegetable and fruits, grain products, milk products, meat and alternatives intake.	Y	+++
Duncan et al. (2008)(59)	Skipping breakfast 3-4 days/week (OR 2.24; 95% CI 1.08-4.64) but not skipping breakfast always (OR 1.38, 95% CI 0.34-5.56) or 5-6 days/week (OR 1.47; 95% CI 0.73-2.98) was associated with being overfat ((body fat ≥25% in boys, ≥30% in girls) compared with skipping breakfast ≤2 days/week.	Age, sex, ethnicity, socioeconomic status, physical activity, active transport, sports participations, lunch bought at school, breakfast, fast food, sugary drink, weekday sleep, weekend sleep.	I	+++
Fiore et al. (2006)(64)	Eating breakfast every day (OR 1.38; 95% CI 0.75-2.52) or some days (OR 1.24; 95% CI 0.68-2.26) did not show a statistically significant association with healthful weight compared with rarely or never eating breakfast.	Age, sex, race/ethnicity, caregiver education, exercise, exercise programs in past year, poverty-to-income ratio, energy intake, parental obesity, standardized math score, standardized reading score, asthma, water consumption, television viewing, total dietary fiber.	N	+++
Fonseca et al. (1998)(65)	The frequency of eating breakfast was not associated with overweight in boys (β 0.16, p=0.52) but it was associated with overweight in girls (β 0.49, p=0.03).	Age, total energy, television and videogames use, menarche (in girls), parental obesity, diet to lose weight.	Sex interaction	+++
Gikas et al. (2003)(72)	Skipping breakfast was associated with overweight/obesity (OR 1.90; 95% CI 1.12-2.88) compared with eating breakfast. Skipping breakfast was associated with higher BMI compared with eating breakfast (22.6±3 versus 21.4±2.8 kg/m^2, p=0.008).	Age, sex, father's education, area of residence.	Y	+

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Skipping breakfast, lunch or dinner: <u>Cross-sectional</u> studies in <u>children and/or adolescents</u> (continued)

Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Hamaideh et al. (2010)(76)	Eating breakfast regularly was associated with higher BMI (β 0.11; p≤0.01).	Age, sex, parental education, family's income level, physical activity, perceived stress, number of family members, parental weight and height status, place of residence (urban or rural), daily sleeping hours, daily time spent at home in sitting activities, daily eating frequency, dietary intake (fruits, vegetables, meat, legumes, nondiet soft drinks, fast food intake, additional light meals (chocolate, cake, potato chips), fried meals.	Y (higher BMI in those eating breakfast regularly)	+++
Harding et al. (2008)(77)	Skipping breakfast 'always or sometimes' was associated with overweight in boys (OR 1.53; 95% CI 1.27-1.84) and in girls (OR 1.66; 95% CI 1.38-2.01) compared with skipping breakfast rarely. Skipping breakfast 'always or sometimes' was associated with obesity in boys (OR 2.06; 95% CI 1.57-2.70) and in girls (OR 1.74; 95% CI 1.30-2.34) compared with skipping breakfast rarely.	Age, socioeconomic circumstances, family type, height, pubertal stage.	Y	+
Henriquez Sanchez et al. (2008)(79)	Skipping breakfast was associated with higher frequency of overweight in boys (18.2% and 10.5%, respectively) and in girls (17.5% and 11.5%, respectively) compared with eating breakfast. Skipping breakfast was associated with higher frequency of obesity in boys (27.3% and 11.3%, respectively) and in girls (30.0% and 16.5%, respectively) compared with eating breakfast.	Crude analysis.	Y	0
Hirschler et al. (2009)(81)	Eating breakfast was associated with lower frequency of overweight/obesity (OR 0.43; 95% CI 0.19-0.97) compared with not eating breakfast.	Maternal education, socioeconomic class, maternal BMI, television viewing, intake of sweet beverages, fruits, vegetables, and milk.	Y	+++
Isacco et al. (2010)(86)	Higher breakfast eating frequency was associated with lower BMI Z score ($p<0.001$), lower waist circumference ($p<0.001$) and lower skinfold thickness measures ($p<0.001$).	Crude analysis.	Y	0
Kapantais et al. (2011)(91)	Eating breakfast ≥2 times/week was associated with a lower BMI compared with eating breakfast <2 times/week in boys (21.9 and 23.2 kg/m^2, respectively; $p=0.001$) and in girls (20.9 and 21.9 kg/m^2, respectively; $p=0.001$).	Crude analysis.	Y	0
Keski-Rahkonen et al. (2003)(95)	A higher BMI was associated with a greater likelihood of having breakfast only a few times a week (vs. every day) or just once a week or less (vs. every day) in adolescents. In particular, compared with adolescents with a BMI <20 kg/m^2, those with a BMI ≥25 kg/m^2 had an OR 1.41 (95% CI 0.93-2.14) of having breakfast only a few times a week and an OR 2.00 (95% CI 1.32-3.01) of having it just once a week or less. Please note that this work aimed to identify determinants of skipping breakfast, not determinants of BMI.	Sex, family socioeconomic status, education at 16y and at 17y, exercise, smoking, alcohol use, behavioral disinhibition at 17y, age of puberty onset, intake of tea, coffee, caffeinated soda, milk and cocoa.	Y	++

Skipping breakfast, lunch or dinner: Cross-sectional studies in children and/or adolescents (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Kosti et al. (2007)(98)	Eating breakfast >5 times/week did not show a statistically significant association with overweight/obesity in boys (OR 0.88; 95% CI 0.59-1.30) but it was associated with lower frequency of overweight/obesity in girls (OR 0.59; 95% CI 0.37-0.95) compared with eating breakfast ≤5 times/week.	Crude analysis.	Sex interaction	0
Maddah (2009a)(105)	Skipping breakfast was associated with overweight/obesity both in urban (OR 1.96; 95% CI 1.52-2.35) and in rural girls (OR 2.23; 95% CI 1.37-3.65) compared with eating breakfast.	Age, maternal education, walking, television viewing, age of menarche, birth weight.	Y	++
Maddah et al. (2009b)(106)	Skipping breakfast was more frequent in those with overweight than in those with normal weight both in urban (62.7%, 53.5%, respectively; p<0.001) and in rural girls (65.8%, 48.8%, respectively; p<0.001).	Crude analysis.	Y	0
Maddah et al. (2010)(107)	Skipping breakfast was associated with overweight/obesity (OR 1.4; 95% CI 1.2-1.7) compared with eating breakfast.	Age, sex, maternal education level, walking, television viewing, birth rank, mother's employment, parental overweight/obesity, birth weight.	Y	++
Mota et al. (2008)(117)	Eating breakfast was not associated with overweight/obesity in boys (OR 0.98; 95 % CI 0.43-2.20) and in girls (OR 1.39; 95 % CI 0.59-3.31) compared with skipping breakfast.	Meal frequency, physical activity.	N	0
Moreno et al. (2005)(116)	Compared with not skipping breakfast, skipping breakfast was associated with higher BMI in boys aged 15 years (22.52 and 24.21 kg/m^2, respectively) and in girls aged 14 years (21.21 and 23.46 kg/m^2, respectively) and 17 years (21.60 and 23.11 kg/m^2, respectively) (p<0.05). Skipping breakfast was not associated with BMI in boys aged 14, 16 and 17 years, and in girls aged 15, and 16 years (p>0.05).	Crude analysis.	Y (but certain variation with age)	0
Nagel et al. (2009)(119)	Skipping breakfast was associated with overweight (OR 1.73; 95% CI 1.13-2.64) and with obesity (OR 2.50; 95% CI 1.19-5.29) compared with eating breakfast.	Crude analysis.	Y	0
Nicklas et al. (2004)(122)	Skipping breakfast was not associated with overweight status (OR 1.22; 95% CI 0.87-1.71) compared with not skipping breakfast.	Sex, ethnicity, total energy intake, study year.	N	++
Ortega et al. (1998)(128)	Skipping breakfast always was more frequent in overweight and obese boys (3.3%) and girls (8.7%) than in normal-weight boys (2.3%) and girls (1.7%) (p<0.05).	Crude analysis.	Y	0
Panagiotakos et al. (2008)(130)	Daily eating breakfast did not show a statistically significant association with overweight/obesity in boys (OR 0.51; 95% CI 0.25-1.05) but it was associated with lower frequency of overweight/obesity in girls (OR 0.27; 95% CI 0.12-0.64) compared with skipping breakfast.	Physical activity, number of meals/day, cereal intake for breakfast.	Y	+++

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Skipping breakfast, lunch or dinner: <u>Cross-sectional</u> studies in <u>children and/or adolescents</u> (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Pirincci et al. (2010)(135)	Having breakfast was associated with lower frequency of overweight and obesity (OR 0.71; 95% CI 0.54-0.94) compared with skipping breakfast.	Crude analysis.	Y	0
Roseman et al. (2007)(136)	Skipping breakfast was more frequent in children with overweight (X^2 22.40, p<0.001) and in children at risk of overweight (X^2 10.79, p=0.013) than in children with normal (or "healthy") weight.	Crude analysis.	Y	0
Sandercock et al. (2010)(138)	Skipping breakfast always was not associated with obesity in boys (OR 1.62; 95% CI 0.82-3.22) but it was associated with obesity in girls (OR 1.92; 95% CI 1.01-3.61) compared with always eating breakfast. Skipping breakfast sometimes was associated with obesity in boys (OR 1.82; 95% CI 1.24-2.67) but not in girls (OR 1.12; 95% CI 0.71-1.77) compared with always eating breakfast.	Age.	I	+
Serra-Majem et al. (2006)(141)	Eating breakfast regularly was associated with lower frequency of obesity in children aged 2 to 13 years (OR 0.73; 95% CI 0.32-0.94) and in those aged 14 to 24 years (OR 0.64; 95% CI 0.37-0.88) compared with not having breakfast regularly. Eating breakfast sometimes was not associated with obesity in children aged 2 to 13 years (OR 0.95; 95% CI 0.69-1.13) and in those aged 14 to 24 years (OR 1.01; 95% CI 0.83-1.42) compared with skipping not having breakfast regularly.	Age, sex, mother's education, family socioeconomic level, geographic region, locality size, birth weight (only for those aged 2 to 13 years), breastfeeding(only for those aged 2 to 13 years), fruit and vegetable consumption, regular consumption of buns and snacks, sugared drinks consumption, time spent watching television daily, regular sport practice.	Y	+++
Sun et al. (2009)(149)	Eating breakfast rarely (OR 2.59; 95% CI 1.05-6.40) and almost daily (OR 1.85; 95% CI 1.23-2.79) but not eating breakfast sometimes (OR 1.49; 95% CI 0.80-2.77) were associated with overweight in boys compared with eating breakfast daily. Eating breakfast rarely (OR 7.93; 95% CI 2.79-22.53) but not sometimes (OR 1.19; 95% CI 0.81-1.76) and almost daily (OR 1.76; 95% CI 0.95-3.26) were associated with overweight in girls compared with eating breakfast daily.	Age, paternal overweight, maternal overweight, breakfast eating frequency, nighttime snacking, eating speed, eating volume, physical activity, television watching time, video game playing time, sleep duration.	Y	++
Terres et al. (2006)(152)	Skipping meals was associated with overweight (PR 1.69; 95% CI 1.29-2.21) and with obesity (PR 2.54; 95 CI 1.22-5.29) compared with not skipping meals.	Age, physical activity outside school, watching television, adolescent's schooling, mother's schooling, obese parents, sexual maturation, dieting, tobacco use, minor psychiatric disorders.	Y	+++
Thompson-McCormick et al. (2010)(155)	Breakfast skipping was associated with overweight (OR 1.15; 95% CI 1.06-1.26) and with obesity (OR 1.18; 95% CI 1.05-1.33) compared with not skipping breakfast. Breakfast skipping was not associated with obesity (OR 1.09; 95% CI 0.96-1.23) compared with not skipping breakfast after further adjustment for eating disorder.	Age, peri-urban school location, low relative material wealth, perceived feasibility of and desire for upward social mobility, perceived Western/global cultural knowledge and competencies, Eating Disorder Examination Questionnaire (EDE-Q) global score.	Y	+

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Skipping breakfast, lunch or dinner: <u>Cross-sectional</u> studies in <u>children and/or adolescents</u> (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Toschke et al. (2009)(158)	Skipping breakfast (not eating breakfast each day) was associated with obesity ($p<0.05$) compared with regular breakfast consumption.	Crude analysis.	Y	0
Utter et al. (2007)(160)	Skipping breakfast was associated with higher BMI (22.1 kg/m^2) compared with eating breakfast sometimes (21.5 kg/m^2) or usually (18.7 kg/m^2) ($p=0.002$)	Age, sex, ethnicity, physical activity, socioeconomic status.	Y	++
Vagstrand et al. (2007)(161)	Breakfast frequency was not associated with percentage of body fat ($p>0.05$).	Crude analysis.	N	0
Vanelli et al. (2005)(163)	Skipping breakfast was associated with higher frequency of overweight (27.5 and 9.1%, respectively; $p=0.01$) and obesity (9.6 and 4.5%, respectively; $p=0.04$) compared with breakfast eating.	Crude analysis.	Y	0
Veltsista et al. (2010)(164)	Daily eating breakfast was associated with lower frequency of overweight/obesity in boys (Finnish: OR 0.72, 95% CI 0.54-0.95; Greek: OR 0.73, 95% CI 0.53-0.97) but not in girls (Finnish: OR 1.01, 95% CI 0.75-1.37; Greek: OR 1.07, 95% CI 0.70-1.65) compared with skipping breakfast ≥1 day/week.	Socioeconomic status, weight control, fear of becoming fat, mother's BMI, father's BMI.	Sex interaction	+
Veugelers et al. (2005)(165)	Skipping breakfast was associated with overweight (OR 1.50; 95% CI 1.06-2.13) compared with usually eating breakfast. Skipping <u>lunch</u> at school was not associated with overweight (OR 1.08; 95% CI 0.63-1.86) compared with bringing lunch from home.	For skipping breakfast: crude analysis. For skipping lunch: parental education, participation in physical activities, frequency of physical education classes in school, lunch and family supper.	Y N	0 +++
Videon et al. (2003)(166)	Skipping breakfast was associated with overweight self perception (OR 1.94; 95% CI 1.72-2.20) compared with not skipping breakfast.	Age, sex, race/ethnicity, parental education, parental influence (presence, food decision-making, family meals).	Y	+
Wolfe et al. (1994)(170)	Skipping breakfast was associated with overweight (β 0.63, $p<0.05$).	Age, sex, race, grade, age within grade, height within grade, socioeconomic status, family structure, school lunch, number of siblings, interactions between socioeconomic status and family structure, height and sex, and between breakfast and family structure.	Y	+
Skipping breakfast, lunch or dinner: <u>Longitudinal</u> studies in <u>children and/or adolescents</u>				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Affenito et al. (2005)(19)	Skipping breakfast (0-3 days/week) did not predict BMI in adjusted analysis ($x^2=3.10$; $p=0.38$).	Age, race, parental education, energy intake, physical activity, site, site-by-age and race-by-age interaction terms.	N	+++
Albertson et al. (2007)(22)	Eating breakfast ≥1 day/week was not associated with a change in BMI Z score after 10-y follow-up in girls with median baseline BMI Z score (β 0.02; 95% CI -0.01, 0.05), but it was associated with a decrease in BMI Z score in girls with baseline BMI Z score at the 95^{th} percentile (β -0.04; 95% CI -0.08, -0.01) and at the 97^{th} percentile (β -0.05; 95% CI -0.10, -0.01).	Race, parental education, physical activity, energy intake, BMI Z score at baseline.	Weight interaction	+++

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Skipping breakfast, lunch or dinner: Longitudinal studies in children and/or adolescents (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Barton et al. (2005)(29)	Number of days eating breakfast (out of 3 possible days) was not predictive of BMI Z score or risk of overweight (x^2=4.54 and 4.98, respectively; p>0.17).	Age, parental education, physical activity, and energy intake number of parents, study site.	N	+++
Berkey et al. (2003)(32)	Skipping breakfast (never eating) was associated with a decrease in BMI after 1-y period in overweight boys (β -0.70, p=0.01) and girls (β -0.47, p=0.01), but not in normal weight boys (β 0.22, p=0.11) and girls (β 0.10, p=0.09) compared with eating breakfast ≥5 days/week.	Age, race, physical activity, sedentariness, menarche (girls), Tanner stage, prior BMI Z score, height growth during the year, cereal consumption, energy intake.	Weight interaction	+++
Merten et al. (2009)(115)	Eating breakfast ≥4 days/week was associated with lower frequency of chronic obesity (OR 0.59; 95% CI 0.52-0.68) compared with eating breakfast <4 days/week.	Sex, race, community disadvantage, family poverty, parental presence in adolescence, community disadvantage and sex interaction.	Y	+
Neutzling et al. (2003)(120)	Eating breakfast daily was not associated with obesity (OR 0.63; 95% CI 0.36-1.10) compared with eating breakfast not daily.	Mother's and father's BMI, birth weight, breast feeding, self perception of overweight before age 10 years, physical activity outside school, hours of television viewing, video games and computer, number of daily meals, soft drinks, fruit and vegetables, dieting for weight loss purposes.	N	+++
Niemeier et al. (2006)(123)	The number of days eating breakfast at baseline (β -0.02, p<0.001) and changing breakfast consumption over the follow up (β -0.01, p<0.01) were associated with BMI Z score after 5 years of follow up.	Age, sex, race/ethnicity, parental education, physical activity, BMI Z score at baseline, maternal obesity, month of interview, sedentary behavior, change in sedentary behavior over the follow up.	Y	++
Timlin et al. (2008)(156)	The lower breakfast eating frequency was cross-sectionally associated with a higher BMI both at baseline (p<0.01) and at the end of follow up (p<0.01). Breakfast frequency at baseline was not associated with change in BMI over the follow up (p>0.05).	Cross-sectional analysis: age, sex, race, socioeconomic status, exercise, smoking, liquor use, total calories, carbohydrates and fiber, percentage of total calories from fat, milk, cold cereal, juices and wheat bread intake, being too rushed to eat, dieting in the past year, skipping meals to control weight, concern about current weight being teased about weight, skipping meals, eating little in the past year to control weight. Longitudinal analysis: as in cross-sectional plus BMI at baseline.	Y (cross-sectionally) N (prospectively)	+++

Skipping breakfast, lunch or dinner: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Al-Rethaiaa et al. (2010)(21)	Breakfast eating frequency was not associated with BMI (p=0.075) and with body fat percent (p=0.464).	Crude analysis.	N	0

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Skipping breakfast, lunch or dinner: Cross-sectional studies in adults (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Amosa et al. (2001)(24)	Skipping breakfast was associated with higher frequency of obesity in Europeans ($p=0.002$) but not in Polynesian women ($p>0.05$) living at New Zealand.	Crude analysis.	Ethnic interaction	0
Berg et al. (2009)(31)	Skipping breakfast (OR 1.41; 95% CI 1.05-1.90) and skipping lunch (OR 1.31; 95% CI 1.04-1.66) were associated with obesity compared with not skipping those meals.	Age, sex, education, physical activity, smoking, employment status.	Y	++
Boo et al. (2010)(43)	Skipping breakfast and the median number of days having breakfast/week were associated with overweight/obesity ($p=0.04$, $p=0.01$, respectively).	Crude analysis.	Y	0
Cho et al. (2003)(48)	Skipping breakfast was associated with higher BMI (26.92 ± 0.20 kg/m^2) compared with eating at breakfast ready-to-eat cereal (26.03 ± 0.19 kg/m^2), cooked cereal (25.46 ± 0.22 kg/m^2), or quick breads (26.16 ± 0.19 kg/m^2) ($p\leq0.01$).	Age, sex, race, physical activity, smoking, alcohol intake, poverty level.	Y	++
Grujić et al. (2009)(74)	Skipping breakfast (never/sometimes eating) was not associated with obesity/overweight (OR 1.10; 95% CI 0.94-1.29) compared with regular breakfast eating.	Age, sex, educational level, income, frequency of physical activity, frequency of watching television, marital status, type of settlements, regular intake of breakfast, lunch, supper and snacks.	N	+++
Hingorjo et al. (2009)(80)	Skipping breakfast was associated with obesity (OR 2.39; confidence interval or statistical significance not reported).	Crude analysis.	Y	0
Huang et al. (2010)(85)	Skipping breakfast was associated with obesity (OR 1.34; 95% CI 1.15-1.56) compared with not skipping breakfast. Skipping breakfast 1-6 times/week was associated with obesity compared with skipping breakfast 4-5 times/week (OR 1.37; 95% CI 1.17-1.60) or compared with skipping breakfast <4 times/week (OR 1.23; 95% CI 1.06-1.44).	Age, sex, educational level, exercise habit, monthly income, marital status, cigarette smoking, alcohol consumption, betel quid chewing.	Y	++
Kant et al. (2008)(90)	Compared with eating breakfast, skipping breakfast was not associated with BMI in men (28.0 and 27.9 kg/m^2, respectively; $p=0.7$) but it was associated with higher BMI in women (27.9 and 29.4 kg/m^2, respectively; $p=0.001$).	Age, sex, race-ethnicity, education, leisure time physical activity, poverty income ratio, smoking status, survey wave.	Sex interaction	++
Keski-Rahkonen et al. (2003)(95)	A higher BMI was associated with a greater likelihood of having breakfast only a few times a week (vs. every day) or just once a week or less (vs. every day) in adults. In particular, compared with adults with a BMI <30 kg/m^2, those with a BMI $\geq$30 kg/m^2 had an OR1.98 (95% CI 1.07-3.65) of having breakfast only a few times a week and an OR 1.11 (95% CI 0.72-1.71) of having it just once a week or less. Please note that this work aimed to identify determinants of skipping breakfast, not determinants of BMI.	Age, sex, highest education, exercise, smoking, alcohol use.	Y	++

Skipping breakfast, lunch or dinner: Cross-sectional studies in adults (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Ma et al. (2003)(104)	Skipping breakfast was associated with obesity (OR 4.50; 95% CI 1.57-12.90) compared with regular breakfast consumption.	Age, sex, education, total physical activity, total energy intake.	Y	+++
Marin-Guerrero et al. (2008)(109)	Skipping breakfast was associated with obesity in men (OR 1.58; 95% CI 1.29-1.93) an in women (OR 1.53; 95% CI 1.15-2.03) compared with having breakfast at home. Skipping <u>lunch</u> was not associated with obesity in men (OR 0.19; 95% CI 0.03-1.31) an in women (OR 1.15; 95% CI 0.48-2.72) compared with having lunch at home. Skipping <u>dinner</u> was not associated with obesity in men (OR 1.29; 95% CI 0.84-1.98), but it was associated with obesity in women (OR 1.66; 95% CI 1.20-2.29) compared with having dinner at home.	Age, educational level, physical activity, smoking, alcohol consumption, health status, size of town of residence, marital status.	Y (for breakfast) N (for lunch or dinner)	++
Musaiger et al. (1995)(118)	Eating breakfast (OR 0.97; 95% CI 0.41-2.34), <u>lunch</u> (OR 2.18; 95% CI 0.66-7.91) and <u>dinner</u> (OR 0.80; 95% CI 0.24-2.82) were not found to be associated with obesity compared with eating those meals.	Crude analysis.	N	0
Nooyens et al. (2005)(125)	The frequency of eating breakfast was not associated with change in body weight (β 0.04 kg/y; p=0.21), but it was associated with an increased waist circumference (β 0.10 cm/y; p=0.01).	Age, smoking, physical activity, energy intake, type of job, retirement during follow up, pasta intake, fruit intake, sugar soft drinks intake, alcoholic beverages intake, carbohydrates intake, fiber density, breakfast frequency at baseline.	I	+++
Shin et al. (2009)(143)	Skipping breakfast was not associated with the <u>metabolic syndrome</u> (OR 1.10; 95% CI 0.88-1.37) compared with always eating breakfast.	Age, physical activity, smoking, family history of type 2 diabetes.	N	++
Song et al. (2005)(147)	Eating breakfast every day was not associated with a BMI ≥25 kg/m^2 (OR 0.87, 95% CI 0.68-1.10) compared with not eating breakfast.	Age, sex, ethnicity, exercise, energy intake, smoking, weight control, ready-to-eat-cereal consumption.	N	+++

Skipping breakfast, lunch or dinner: Longitudinal studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Goto et al. (2010)(73)	Frequently skipping breakfast was associated with a BMI gain ≥5% (OR 1.34; 95% CI 1.12-1.61).	Exercise frequency, alcohol drinking, preference for fatty food, living alone.	Y	++
van der Heijden et al. (2007)(162)	Compared with men who did not consume breakfast, men who did consume breakfast had a 23% lower risk of a 5-kg weight gain after adjustment for age (HR 0.77; 95% CI 0.72- 0.82). Further adjustment for potential confounders (see next column) weakened the association (HR 0.87; 95% CI 0.82-0.93). Dietary factors (nutrient and fiber intake, number of eating occasion) explained part of the association, because after adjustment for such factors the HR was 0.91 (95% CI 0.85-0.97).	Age, physical activity, marital status, work status, baseline BMI, smoking, alcohol intake, weight lifting.	Y	++

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S3. Association between daily eating frequency and excess weight, by study design and population.

Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Daily eating frequency: Cross-sectional studies in children and/or adolescents				
Barba et al. (2006)(27)	Greater daily eating frequency was associated with lower BMI (p=0.001). Mean BMI among those eating ≥5, 4 and ≤3 times/day was 18.8, 19.7 and 20.5 kg/m^2, respectively. Greater daily eating frequency was associated with lower WC (p=0.001). Mean WC among those eating ≥5, 4 and ≤3 times/day was 63.9, 66.6 and 68.0 cm, respectively.	Age, sex, parental educational level, physical activity, birth weight, parental overweight.	Y	++
Bibiloni et al. (2010)(39)	Compared with eating ≥5 meals/day, eating 1-3 meals/day was shown to be associated with obesity in boys (OR 4.99; 95% CI 2.1-11.54) and (marginally) in girls (OR 2.20; 95% CI 0.99-4.89). Eating 4 meals/day was associated with obesity in boys (OR 2.60; 95% CI 1.13-5.98) but not in girls (OR 0.83; 95% CI 0.32-2.16)	Age, parental education level, physical activity level, parental socioeconomic status, place of birth, hours of sleep, breakfast habit, sweet or salty snacks intake, attention to mass media, alcohol consumption, current smoking habit.	Y	+++
Huang et al. (2004)(84)	Daily eating frequency was associated with lower BMI percentile in boys aged 12 to 19 years (β -3.843, p=0.01) but not in boys of other ages and in girls (p>0.05).	Ethnicity, percentage above poverty, urbanicity, geographic region, daily television viewing.	I	++
Kontogianni et al. (2010)(97)	Daily eating frequency was not associated with BMI in children aged 3-12 years (p=0.83) and in adolescents aged 13-18 (p=0.38).	Crude analysis	N	0
Kosti et al. (2007)(98)	Eating ≥3 meals/day (including snacks) was associated with lower frequency of overweight/obesity in boys (OR 0.55; 95% CI 0.36-0.86) but not in girls (OR 0.77; 95% CI 0.46-1.30) compared with eating <3 meals/day.	Crude analysis	Sex interaction	0
Lagiou et al. (2008)(100)	Daily eating frequency was associated with lower frequency of overweight (OR 0.61; 95% CI 0.48-0.76).	Age, sex, paternal education, inactivity except sleep, parental marital status, total energy intake, energy from protein, energy from fat, birth place, birth order, daily consumption of beverages, total energy intake, energy from protein, energy from fat, parental pressure for eating.	Y	+++
McConahy et al. (2002)(111)	Daily number of eating occasions was not associated with percentile body weight (p>0.05).	Crude analysis	N	0
Mota et al. (2008)(117)	Eating ≥5 meals/day was not found to be associated with overweight/obesity in boys (OR 1.44, 95 % CI 0.86-2.97) and in girls (OR 1.33; 95% CI 0.75-2.36) compared with eating ≤3 meals/day. Eating 4 meals/day was associated with overweight/obesity in boys (OR 2.75; 95 % CI 1.29-5.83) and in girls (OR 1.97; 95% CI 1.00-3.96) compared with eating ≤3 meals/day.	Breakfast skipping, physical activity	I	0
Nicklas et al. (2003)(121)	Daily eating frequency was not associated with overweight (OR 0.91; 95% CI 0.72-1.15).	Age, sex, ethnicity, total calorie intake, study year	N	+

Daily eating frequency: Cross-sectional studies in children and/or adolescents (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Nicklas et al. (2004)(122)	Eating <3 meals/day was not associated with overweight status (OR 1.25; 95% CI 0.92-1.70) compared with eating ≥3 meals/day. The number of total eating episodes was not associated with overweight (OR 0.97; 95% CI 0.90-1.05).	Sex, ethnicity, total energy intake, study year.	N	++
Panagiotakos et al. (2008)(130)	Eating 3 and >3meals/day were not associated with overweight/obesity in boys (OR 1.19, 95% CI 0.58-2.47; OR 1.09, 95% CI 0.55-2.18, respectively) and in girls (OR 0.64, 95% CI 0.28-1.48; OR 0.59, 95% CI 0.26-1.32, respectively) compared with eating 1 or 2 meals/day.	Physical activity, cereal intake for breakfast, daily breakfast consumption.	N	+++
Toschke et al. (2005)(157)	Eating ≥5 meals/day was associated with lower frequency of overweight (OR 0.56; 95% CI 0.42-0.75) and obesity (OR 0.51; 95% CI 0.29-0.89) compared with eating ≤3 meals/day. Eating 4 meals/day was associated with a lower frequency of overweight (OR 0.73; 95% CI 0.56-0.96) but it was not associated with obesity (OR 0.73, 95% CI 0.44-1.21) compared with eating ≤3 meals/day.	Parental education, parental obesity, daily watching television, breastfeeding, little physical activity at school entry, smoking in pregnancy, regular snacking while watching television.	Y	+++
Toschke et al. (2009)(158)	Eating ≥5 meals/day was associated with a lower frequency of overweight/obesity (OR 0.57; 95% CI 0.37-0.88) compared with eating ≤3 meals/day.	Parental education, migrational background, maternal smoking in pregnancy, breastfeeding, having siblings, parental overweight, low physical activity; daily use of television or personal computer, snacking.	Y	+++
Vik et al. (2010)(167)	Eating ≤1 meals/day was not associated with overweight (OR 0.8; 95% CI 0.3-1.9) but eating 2 meals/day (OR 1.8; 95% CI 1.2-2.7) or 3 meals/day (OR 1.6; 95% CI 1.2-2.3) were associated with overweight compared with eating 4 meals/day.	Sex, education plans, physical activity, fruit and vegetable intake, consumption of unhealthy snacks, television and computer viewing, dieting.	Y	+++

Daily eating frequency: Longitudinal studies in children and/or adolescents				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Fabry et al. (1966)(62)	Eating 3 meals/day during 1-y was associated with higher weight-height index of proportionality in boys aged 11 to 16 years ($p<0.05$) and in girls aged 10 to 16 years ($p<0.001$) compared with eating 5 or 7 meals/day. No significant associations between daily eating frequency and index of proportionality were found in children with 6 to 10 years of age.	Crude analysis.	Age interaction	0
Franko et al. (2008)(68)	Eating ≥3 meals/day was associated with higher BMI Z scores (β -0.0472, $p<0.0001$) but not with overweight (OR 0.91; 95% CI 0.79-1.05) compared with eating <3 meals/day.	Parental education, race, follow-up visit, study site, hours watching television per week, physical activity score, average daily energy intake.	Y	+++
He et al. (2000)(78)	Eating >3 meals/day was not associated with obesity in children aged 0.1-2.9 years (OR 0.84; 95% CI 0.53-1.34) or in children aged 3-6.9 years (OR 1.00; 95% CI 0.78-1.30) compared with eating fewer meals.	Crude analysis	N	0

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Daily eating frequency: Longitudinal studies in children and/or adolescents (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Neutzling et al. (2003)(120)	Eating >3 meals/day was associated with lower frequency of obesity (OR 0.54; 95% CI 0.29-1.00) compared with eating ≤3 meals/day.	Mother's and father's BMI, birth weight, breast feeding, self perception of overweight before age 10 years, physical activity outside school, hours of television viewing, video games and computer, having breakfast, soft drinks, fruit and vegetables, dieting for weight loss purposes.	Y	+++
Novaes et al. (2008)(126)	Eating ≤3meals/day (OR 1.50; 95% CI 0.20-12.77) compared with eating <3 meals/day, and eating >6 meals/day (OR 1.00; 95% CI 0.16-6.17) compared with eating ≤6 meals/day were not associated with obesity.	Crude analysis.	N	0
Thompson et al. (2006)(154)	Eating 4-5 meals/day was associated with an increase in BMI Z score after 10 years of follow-up (β 0.24, p=0.028) compared with eating ≥6 times/day.	Age, race, parental education, physical activity, household income, parental BMI, baseline BMI Z score, follow-up time.	Y	++
Daily eating frequency: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Al-Isa et al. (1999)(20)	Daily eating frequency was associated with obesity grade 1 and 2 (p<0.05). Eating 3 meals/day was more frequent in the non-obese than in the obese grade 2 (54.5% and 48%, respectively), and eating 1 meal/day was less frequent in the non-obese than in the obese grade 2 (4.2% and 8.0%, respectively).	Crude analysis.	Y	0
Al-Rethaiaa et al. (2010)(21)	Daily eating frequency was not associated with BMI (p=0.108) and with body fat percent (p=0.795).	Crude analysis.	N	0
Bellisle et al. (1995)(30)	Daily eating frequency was not associated with BMI (p>0.05).	Adjustment variables not reported.	N	-
Berg et al. (2008)(31)	Daily eating frequency was not associated with obesity (OR 0.97; 95% CI 0.89-1.06).	Age, sex, education, physical activity, smoking, employment status.	N	++
Berteus Forslund et al. (2002)(33)	Daily eating frequency was greater in obese women than in the reference group (p<0.01)	Crude analysis.	Y (higher frequency with obesity)	0
Berteus Forslund et al. (2005)(34)	Daily eating frequency was associated with obesity (OR 1.21; 95% CI 1.15-1.27).	Age, energy intake.	Y	+
Boo et al. (2010)(43)	Daily eating frequency was not associated with overweight/obesity (p=0.6).	Crude analysis.	N	0
Fabry et al. (1964)(61)	Eating ≤3 times/day was associated with overweight compared with eating ≥5 meals/day (p<0.01).	Crude analysis.	Y	0
Gigante et al. (1997)(71)	Eating >3 times/day showed a tendency to a lower frequency of obesity in men (OR 0.58; 95% CI 0.33-1.04) and a statistically significant reduction of obesity in women (OR 0.56; 95% CI 0.37-0.86) compared with eating ≤3 meals/day.	Age, other demographic variables, socio economic variables, physical activity, reported morbidity, sugar intake, oil intake.	Y	+++

Daily eating frequency: <u>Cross-sectional</u> studies in <u>adults</u> (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Holmback et al. (2010)(82)	Eating ≤3 meals/day was not associated with overweight in men (OR 0.94; 95% CI 0.54-1.62) and in women (OR 0.76; 95% CI 0.37-1.57) compared with eating ≥6 meals/day. Eating ≤3 meals/day was associated with obesity in men (OR 2.42; 95% CI 1.02-5.73) but not in women (OR 2.55; 95% CI 0.93-6.98) compared with eating ≥6 times/day. Eating ≤3 meals/day was associated with severe central obesity in men (OR 2.09; 95% CI 1.03-4.27) but not in women (OR 2.01; 95% CI 0.84-4.79) compared with eating ≥6 times/day. Eating 4-5 meals/day was not associated with overweight in men (OR 0.85; 95% CI 0.59-1.22) and in women (OR 0.82; 95% CI 0.60-1.13) compared with eating ≥6 meals/day. Eating 4-5 meals/day was not associated with obesity in men (OR 1.15; 95% CI 0.59-2.22) and in women (OR 1.26; 95% CI 0.77-2.05) compared with eating ≥6 times/day. Eating 4-5 meals/day was not associated with severe central obesity in men (OR 1.64; 95% CI 0.97-2.78) and in women (OR 1.06; 95% CI 0.70-1.66) compared with eating ≥6 times/day.	Age, education, socioeconomic status, energy intake, leisure time physical activity, smoking, alcohol consumption, non-alcohol energy percentage from fat, fiber intake, fruit and vegetables, confectionery foods, soft drinks, cakes and pastries, low-fat meat, low-fat dairy products.	I	+++
Howarth et al. (2007)(83)	Eating >6 times/day was associated with higher BMI in adults aged 20-59 years (β 1.28, p=0.006) and in adults aged 60-90 years (β 2.32, p=0.004) compared to eating ≤3 times/day.	Age, sex, race, education, income, television viewing, current smoking, region, urbanicity, self reported chronic disease.	Y(more obesity in those with higher eating frequency)	++
Ma et al. (2003)(104)	Eating ≥4 meals/day was associated with lower frequency of obesity (OR 0.55; 95% CI 0.33-0.91) compared with eating ≤3 meals/day.	Age, sex, education, total physical activity, total energy intake.	Y	+++
Marin-Guerrero et al. (2008)(109)	Eating 2 times/day was associated with obesity in men (OR 1.63; 95% CI 1.37-1.95) and in women (OR 1.30; 95% CI 1.05-1.62) compared with eating 3-4 times/day. Eating 1 time/day was not associated with obesity in men (OR 1.42; 95% CI 0.94-2.14) and in women (OR 1.11; 95% CI 0.71-1.79) compared with eating 3-4 times/day.	Age, educational level, physical activity, smoking, alcohol consumption, health status, size of town of residence, marital status.	Y	++
Peixoto et al. (2007)(131)	Eating ≥4 meals/day was associated with lower BMI in men (β -0.86, p=0.01) but not in women (p≥0.05) compared to eating <4 meals/day.	Age, physical activity, leisure-time physical activity while commuting to work, income, smoking, alcohol intake, frequency of meat intake, vegetable intake.	Sex interaction	+++
Shin et al. (2009)(143)	Eating 2 times/day was not associated with the <u>metabolic syndrome</u> (OR 1.08; 95% CI 0.88-1.33) compared with eating 3 times/day.	Age, physical activity, smoking, family history of type 2 diabetes.	N	++
Summerbell et al. (1996)(148)	Daily eating frequency was not associated with BMI (β -0.0905, p>0.05).	Crude analysis.	N	0
Wahlqvist et al. (1999)(168)	Daily eating frequency was associated with lower BMI (p<0.01) in Greeks living in Greece and Australia. Daily eating frequency was associated with lower percentage of body fat in Greeks living in Australia (p<0.03) but not in Greeks living in Greece (p>0.05).	Crude analysis.	Y (though certain interaction by country)	0

Daily eating frequency: <u>Longitudinal</u> studies in <u>adults</u>				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Kant et al. (1995)(89)	Daily eating frequency at baseline was not associated with weight change in men (β 0.0211, p=0.86) and in women (β 0.1101, p=0.21). Daily eating frequency at follow up was not associated with weight change in men (β 0.0859, p=0.52) and in women (β 0.2299, p=0.13).	Age, education, race, usual physical activity at baseline and at follow-up, smoking status, alcohol intake, baseline BMI, energy intake, weight change, frequency of eating occasions, length of follow-up, morbidity, special diet status, parity	N	+++
van der Heijden et al. (2007)(162)	Eating 4 meals/day (HR 1.07, 95% CI 1.02-1.14) or ≥5 meals/day (HR 1.15, 95% CI 1.06-1.25) were associated with higher risk of 5-kg weight gain after 10 years of follow-up compared with eating 3 meals/day.	Age, physical activity, marital status, work status, baseline BMI, smoking, alcohol intake, weight lifting.	Y(more obesity in those with higher eating frequency)	++

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S4. Association between snacking and excess weight, by study design and population.

Snacking: Cross-sectional studies in children and/or adolescents				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Bin Zaal et al. (2009)(40)	Always snacking between breakfast and lunch was not associated with obesity in boys (OR 0.6; 95% CI 0.3-1.2) and in girls (OR 0.6; 95% CI 0.3-1.1) compared with never snacking. Frequently snacking between breakfast and lunch was not associated with obesity in boys (OR 0.6; 95% CI 0.3-1.1) but it was associated with lower frequency of obesity in girls (OR 0.5; 95% CI 0.3-0.9) compared with never snacking. Always eating midnight snacks was not associated with obesity in boys (OR 0.5; 95% CI 0.2-1.0) and in girls (OR 1.2, 95% CI 0.6-2.2) compared with never eating midnight snacks.	Crude analysis.	N	0
Bishwalata et al. (2010)(42)	Eating between meals was associated with a lower BMI (OR 0.447; 95% CI 0.293-0.681).	Sex, parental education, self-reported parental obesity, watching television, eating snacks while watching television, taking cold drinks while watching television, playing computer/video games, not playing outdoor games, daily reading time, daily sleeping time, family income, eating vegetables, waist-hip ratio.	Y (lower BMI with eating between meals)	+++
Craig et al. (2010)(51)	Lower snack food consumption was linearly associated with higher BMI in boys aged 5-11 years (p for trend=0.047).	Age, socioeconomic status.	Y (higher BMI in those with lower snack intake)	+
de Gouw et al. (2010)(53)	In adolescents aged 10 to 14 years, mid-morning snacking was not associated with overweight and obesity in boys (OR 0.86; 95% CI 0.57-1.30) and in girls (OR 1.21; 95% CI 0.80-1.81). Not having an afternoon snacking (OR 1.43; 95% CI 1.11-1.84) and not having a besides meals snacking (OR 1.41; 95% CI 1.12-1.77) were associated with overweight and obesity in boys and in girls (OR 1.34; 95% CI 1.03-1.75 and OR 1.46; 95% CI 14-1.86, respectively). In adolescents aged 15 to 18 years, snacking was associated with overweight and obesity in boys but not in girls. Specifically, not having mid-morning snacking (OR 1.76; 95% CI 1.25-2.50), not having afternoon snacking (OR 1.56; 95% CI 1.14-2.15), and not having besides meals snacking (OR 1.71; 95% CI 1.27-2.28) were associated with overweight and obesity in boys. Corresponding values for girls were, respectively: mid-morning snacking (OR 1.15; 95% CI 0.82-1.61), afternoon snacking (OR 1.29; 95% CI 0.97-1.71), and besides meals snacking (OR 1.31; 95% CI 0.99-1.71).	Age, parents' education, school, birth weight, breast-feeding, puberty, parents' BMI, number of inhabitants, family size.	Age and sex interactions	+
Gikas et al. (2003)(72)	Snack consumption (eating sandwiches, cheese pies, croissants, and other snacks between breakfast and lunch) was not associated with BMI (p>0.05).	Crude analysis.	N	0
Huang et al. (2004)(84)	Snack frequency (eating smaller food portions between meals) was not associated with BMI percentile in boys aged 3 to 19 years, and in girl aged 3 to 5 and 12 to 19 years (p>0.05). However, snack frequency was associated with lower BMI percentile in girls aged 6 to 11 years (β -3.447, p=0.02).	Ethnicity, percentage above poverty, urbanicity, geographic region, daily television viewing.	Y (higher BMI in girls with less snacking)	++

Snacking: Cross-sectional studies in children and/or adolescents (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Isacco et al. (2010)(86)	Snacking between meals was associated with higher BMI Z score ($p<0.05$), higher waist circumference ($p<0.001$) and higher skinfold thickness measures ($p<0.001$).	Crude analysis.	Y	0
Keast et al. (2010)(92)	Snacking 1 time/day was not associated with overweight/obesity (OR 0.81, 95 % CI 0.60-1.10) compared with not snacking. Snacking 2, 3, ≥4 times/day were associated with lower frequency of overweight/obesity (OR 0.63, 95 % CI 0.48-0.85; OR 0.56, 95 % CI 0.42-0.76; OR 0.40, 95 % CI 0.29-0.57, respectively) compared with not snacking. Snacking 2, 3, ≥4 times/day were associated with lower frequency of abdominal obesity (OR 0.61, 95 % CI 0.43-0.86; OR 0.41, 95 % CI 0.27-0.61; OR 0.36, 95 % CI 0.21-0.63, respectively) compared with not snacking.	Age, sex, ethnicity, physical activity, income, television or computer use, smoking, and weight loss tried.	Y (more general and abdominal obesity with less snacking)	+++
Kosti et al. (2007)(98)	Eating sweets and snacks (per 1 serving/week) was not associated with overweight/obesity in boys (OR 0.99; 95% CI 0.97-1.00) and in girls (OR 0.99; 95% CI 0.97-1.01) compared with not eating sweets or snacks.	Crude analysis.	N	0
Li et al. (2010)(101)	Snacking (frequently having foods and beverages outside the three main meals) showed an association with a lower frequency of overweight/obesity (OR 0.6; 95% CI 0.4-0.9) compared with not snacking.	Age, sex, residence, household wealth index, parental BMI.	Y (more obesity with less snacking)	+
McDonald et al. (2009)(113)	A higher adherence (upper quartile) to a snacking pattern (e.g. candy, ice cream, packed fried snacks, soda, sugar-sweetened fruit-flavored drinks) showed a marginally significant association with overweight/obesity (PR 1.95; 95% CI 0.99-3.84) compared with a lower adherence (lower quartile).	Age, sex, socioeconomic status, total energy intake, maternal BMI, number of household assets.	Y	+
Mercille et al. (2010)(114)	Number of snacks/day was not associated with BMI ($p>0.05$).	Crude analysis.	N	0
Nicklas et al. (2003)(121)	Number of snacking episodes/day was not associated with overweight (OR 0.98; 95% CI 0.90-1.05).	Age, sex, ethnicity, study year, total energy intake.	N	+
Omuemu et al. (2010)(127)	Daily consumption of snacks (e.g. meat-pies, doughnut, cakes, buns, etc.) was associated with BMI ($p<0.0001$) compared with consumption <1 time/day. Daily snacks consumption was more frequent in adolescents with overweight (7.8 versus 1.9%) and at risk of overweight (65.8 versus 29%) than in healthy weight.	Crude analysis.	Y	0
Sanigorski et al. (2007)(139)	Usual frequency of consumption of packaged snacks was not associated with overweight/obesity. Specifically, eating packaged snacks 2-4 times/week (OR 0.9; 95% CI 0.7-1.2), 5-6 times/week (OR 0.9; 95% CI 0.6-1.2), 1 time/day (OR 1.1; 95% CI 0.8-1.4) and ≥2 times/day (OR 1.0; 95% CI 0.6-2.0) were not associated with overweight/obesity compared with eating packaged snacks ≤1 time/week.	Age, sex, socioeconomic index for areas.	N	+

Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Snacking: <u>Cross-sectional studies</u> in <u>children and/or adolescents</u> (continued)				
Shan et al. (2010)(142)	Eating snacks 1-2 times/week was not associated with overweight (OR 1.14; 95% CI 0.99-1.30) but it was associated with obesity (OR 1.39; 95% CI 1.20-1.61) compared with eating snacks <1 time/week. Eating snacks ≥3 times/week was associated with overweight (OR 1.26; 95% CI 1.13-1.40) and with obesity (OR 1.53; 1.35-1.72) compared with eating snacks <1 time/week.	Age, sex, Tanner stage, urban/rural residence.	Y	+
Serra-Majem et al. (2006)(141)	Eating buns and snacks ≥5 times/week was associated with obesity in children aged 2 to 13 years (OR 1.27; 95% CI 1.05-2.31) and in those aged 14 to 24 years (OR 1.31; 95% CI 1.09-1.92) compared with eating buns and snacks <1time/week. Eating buns and snacks 1 to 4 times/week was not associated with obesity in children aged 2 to 13 years (OR 1.01; 95% CI 0.53-1.98) and in those aged 14 to 24 years (OR 0.75; 95% CI 0.44-1.86) compared with eating buns and snacks <1time/week.	Age, sex, mother's education, family socioeconomic level, geographic region, locality size, birth weight (only for those aged 2 to 13 years), breastfeeding(only for those aged 2 to 13 years), fruit and vegetable consumption, regular breakfast consumption, sugared drinks consumption, time spent watching television daily, regular sport practice.	Y	+++
Sun et al. (2009)(149)	Snacking daily (OR 0.80; 95% CI 0.57-1.12), almost daily (OR 0.82; 95% CI 0.60-1.12) and sometimes (OR 1.14; 95% CI 0.83-1.56) were not associated with overweight in boys compared with rarely snacking. Nighttime snacking in boys was associated with lower frequency of overweight in those doing it daily (OR 0.64; 95% CI 0.49–0.85) or almost daily (OR 0.66; 95% CI 0.44–0.99) compared with doing it rarely. Snacking daily (OR 0.31; 95% CI 0.21-0.47) and almost daily (OR 0.45; 95% CI 0.32-0.63), but not snacking sometimes (OR 0.93; 95% CI 0.66-1.30), were associated with lower frequency of overweight in girls compared with rarely snacking. Nighttime snacking did not show an association with overweight in girls.	Age, paternal overweight, maternal overweight, breakfast eating frequency, nighttime snacking, eating speed, eating volume, physical activity, television watching time, video game playing time, sleep duration.	Y (more overweight with less snacking)	++
Toschke et al. (2009)(158)	<u>Regular</u> snacking sweets, crisps or related products while watching television was not associated with obesity (OR 1.03; 95% CI 0.73-1.46) compared with <u>not regular</u> snacking.	Parental education, migrational background, maternal smoking in pregnancy, breastfeeding, having siblings, parental overweight, low physical activity; daily use of television or personal computer.	N	+++
Vik et al. (2010)(167)	The frequency of consumption of unhealthy snacks (times/week) was associated with lower frequency of overweight (OR 0.93; 95% CI 0.91-0.96).	Sex, education plans, physical activity, fruit and vegetable intake, number of meals consumed the day before, television and computer viewing, dieting.	Y (more overweight with less snacking)	+++
Snacking: <u>Longitudinal</u> studies in <u>children and/or adolescents</u>				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Field et al. (2004)(63)	Intake of snack foods was not found to be associated with annual change in BMI *Z* score compared with not snacking (β -0.006; 95% CI -0.013, 0.001).	Age, age squared, activity, inactivity, Tanner stage, height change, baseline weight, mother's weight status, dieting, total calories.	N	+++

Snacking: Longitudinal studies in children and/or adolescents (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Francis et al. (2003)(66)	Snack frequency (0 to 4 times/day) was not associated with change in BMI after 4 years of follow-up (p>0.05).	Crude analysis.	N	0
Keski-Rahkonen et al. (2007)(96)	Frequent (usually or often) snacking between meals was not associated with overweight defined as $25 \leq BMI < 27$ kg/m^2 in boys (OR 1.3; 95% CI 0.9-1.8), but it was associated in girls (OR 1.6; 95% CI 1.1-2.3) compared with not frequent snacking. Frequent (usually or often) snacking between meals was associated with overweight defined at $27 \leq BMI < 30$ kg/m^2 in boys (OR 2.2; 95% CI 1.5-3.3) and in girls (OR 2.0; 95% CI 1.3.3.1) compared with not frequent snacking. Frequent (usually or often) snacking between meals was associated with obesity in boys (OR 3.0; 95% CI 1.7-5.5) and in girls (OR 2.7; 95% CI 1.6-4.6) compared with not frequent snacking. Frequent (usually or often) replacing meals by snacks was not associated with overweight defined as $25 \leq BMI < 27$ kg/m^2 in boys (OR 0.7; 95% CI 0.4-1.1) and in girls (OR 0.9; 95% CI 0.6-1.5) compared with not frequent. Frequent (usually or often) replacing meals by snacks was associated with overweight defined at $27 \leq BMI < 30$ kg/m^2 in boys (OR1.9; 95% CI 1.1-3.2) but not in girls (OR 1.3; 95% CI 0.7-2.5) compared with not frequent. Frequent (usually or often) replacing meals by snacks was not associated with obesity in boys (OR 1.4; 95% CI 0.6-3.0) and in girls (OR 1.4; 95% CI 0.7-2.5) compared with not frequent.	BMI at baseline, clustering within the twin pair.	I	+++
Novaes et al. (2008)(126)	Snacking (substituting meals by snacks at <u>dinner</u>) was not associated with obesity (OR 1.75; 95% CI 0.68-4.54). .	Crude analysis.	N	0
Phillips et al. (2004)(134)	The daily frequency of snack foods intake was not associated with BMI *Z* score (p=0.33) and with percentage of body fat (p=0.49).	Age, percentage of calories from protein, parental education.	N	+
Takahashi et al. (1999)(150)	Snacking ≥3 times/day was not found to be associated with obesity (OR 1.22; p>0.05) compared with snacking <3 times/day. Snacking <u>irregularly</u> was associated with obesity (OR 1.30; 95% CI 1.02-1.65) compared with snacking <u>regularly</u>.	For snacking frequency: crude analysis. For snacking regularity: physical activity, obesity of mother, obesity of father, weight at birth, duration of outdoor playtime.	N Y (for regular vs. irregular snacking)	0 ++
Snacking: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Al-Rethaiaa et al. (2010)(21)	Snacking was associated with differences between BMI categories (p=0.018). For example, taking snacks apart from regular meals daily was more frequent in normal weight (35.1%) than in overweight (24.3%) and obese (33.9%). Snacking was not associated with body fat percent (p=0.275).	Crude analysis.	I	0

Snacking: Cross-sectional studies in adults (continued)				
Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Bellisle et al. (1995)(30)	Snack frequency (times/day) was associated with BMI in men (p=0.001) but not in women (p>0.05).	Adjustment variables not reported.	I	-
Berteus Forslund et al. (2002)(33)	Snack frequency (times/day) was greater in obese women compared with the reference group (p<0.0001).	Crude analysis.	Y	0
Berteus Forslund et al. (2005)(34)	Snack frequency (times/day) was associated with obesity (OR 1.27; 95% CI 1.19-1.35).	Age, energy intake.	Y	+
Bezerra et al (2009)(38)	Eating deep-fried snacks away from home ≥1 time/week was not associated with overweight in men (OR 1.09; 95% CI 0.93-1.28) and in women (OR 0.95; 95% CI 0.80-1.13) compared with not eating deep-fried snacks away from home. Eating deep-fried snacks away from home ≥1 time/week was associated with obesity in men (OR 1.30; 95% CI 1.03-1.65) but not in women (OR 1.04; 95% CI 0.84-1.29) compared with not eating deep-fried snacks away from home.	Age, income.	N	+
Boo et al. (2010)(43)	Snacks consumption and the median number of snacks/day were not associated with overweight/obesity (p=0.4, p=0.5, respectively).	Crude analysis.	N	0
Fabry et al. (1964)(61)	Eating 3-4 meals/day with additional snacks between meals was associated with lower frequency of obesity compared with eating ≤3 meals/day without snacking between meals (p<0.05).	Crude analysis.	Y (lower obesity with snacking)	0
Hingorjo et al. (2009)(80)	Taking ≥1 snack/day (french fries, burger, fried food, and pizzas) was associated with obesity (OR 1.58; confidence interval or statistical significance not reported) compared to not snacking.	Crude analysis.	Y	0
Howarth et al. (2007)(83)	Snack frequency (times/day of eating between meals) was associated with BMI in adults aged 20-59 years (β 0.28, p<0.001).	Age, sex, race, education, income, television viewing, current smoking, region, urbanicity, self reported chronic disease.	Y	++
Kent et al. (2009)(93)	Snacking (eating between meals) 1-2 times/day was associated with higher BMI (β 0.99, p=0.043) compared with never/rarely snacking.	Age, education, occupation status, marital status, physical activity, food intake, drink intake, relative breakfast size, dieting to lose weight, cut fat from meat, table salt.	Y	++
Mahmood et al. (2010)(108)	Taking snacks between meals was associated with obesity (OR 5.37; 95% CI 1.51-19.03) compared with not snacking.	Age, marital status.	Y	+

Snacking: <u>Cross-sectional</u> studies in <u>adults</u> (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Marin-Guerrero et al. (2008)(109)	Eating several times/day smaller-sized meals was not associated with obesity in men (OR 1.42; 95% CI 0.99-2.01) but it was associated with obesity in women (OR 1.51; 95% CI 1.17-1.95) compared with eating 3-4 times/day.	Age, educational level, physical activity, smoking, alcohol consumption, health status, size of town of residence, marital status.	Y	++
Perez-Cueto et al (2010)(133)	Giving preference to snack over meals was associated with obesity (OR 1.24; 95% CI 1.13-1.36).	Age, sex, education, locality of residence, financial status, marital status.	Y	+
Sanchez-Villegas et al. (2002)(137)	Snacking (eating between meals) was associated with weight gain (>1-2 kg vs. no gain or no change in weight) in the past 5 years in men (OR 1.88; 95% CI 1.40-2.53) and in women (OR 1.38; 95% CI 1.10-1.73) compared with not snacking.	Age, leisure-time physical activity, television viewing, nap duration, smoking, total energy intake, intake of fat, monounsaturated and satured acids rate, glycemic charge.	Y	+++

Snacking: <u>Longitudinal</u> studies in <u>adults</u>				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Bes-Rastrollo et al. (2010b)(37)	Usual snacking (<u>eating between meals</u>) was associated with weight gain defined as gaining ≥3 kg/year (OR 1.66; 95% CI 1.17-2.35), gaining ≥5 kg/year (OR 2.75; 95% CI 1.17-6.50), and increasing ≥10% of baseline weight (OR 1.29; 95% CI 1.06-1.56) compared with not usual snacking.	Age, sex, physical activity, television viewing, sitting time, total energy intake, smoking, baseline BMI, fast food intake, sugar sweetened beverages, fiber intake, alcohol.	Y	+++
Coakley et al. (1998)(49)	Snacking (<u>eating between meals</u>) at the end of follow up was associated with weight increase in men aged 45-54 years (β 0.25, p≤0.01) and 55-64 years (β 0.31, p≤0.01), but not in men aged ≥65 years (β -0.01, p>0.05)	Baseline weight, height, vigorous activity, television viewing, high blood pressure, high cholesterol.	Y (for those age 45-64 y)	++
Halkjaer et al. (2009)(75)	Snacks consumption was associated with 5-year change in waist circumference in men (β 0.09 cm per 60 Kcal of snack foods consumption; 95% CI 0.05, 0.13) and in women (β 0.06; 95% CI 0.003, 0.11).	Age, sport, hours of sport, energy intake from wine, beer, and spirits, baseline energy intake, baseline waist circumference, body mass index, smoking.	Y	+++
Woo et al. (2008)(171)	Increased <u>variety of snacks</u> intake over the follow-up was associated with incident overweight (OR 1.45; 95% CI 1.06-1.98).	Age, sex, education, physical activity.	Y (for variety of snacks)	++

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S5. Associations between irregular meals and excess weight and metabolic syndrome, by study design and population.

Irregular meals: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Al-Rethaiaa et al. (2010)(21)	Eating meals regularly (constant number of times/day) was not associated with BMI (p=0.09) and with body fat percent (p=0.59).	Crude analysis.	N	0
Shin et al. (2009)(143)	Eating meals irregularly (varying number of times/day) was not associated with the metabolic syndrome (OR 1.04; 95% CI 0.78-1.39) compared with regularly eating 3 times/day.	Age, physical activity, smoking, family history of type 2 diabetes.	N	++
Sierra-Johnson et al. (2008)(144)	Eating breakfast, lunch and dinner usually or always regularly was associated with lower frequency of the metabolic syndrome (OR 0.58; 95% CI 0.41-0.83) compared with eating meals not regularly (sometimes or never eat breakfast, lunch and dinner or evening meal each day).	Sex, education, physical activity, smoking, alcohol intake, fruit intake, vegetable intake, fish intake.	Y	+++

CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S6. Association between eating away-from-home and excess weight, study design and population.

Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Eating away-from-home: Cross-sectional studies in children and adolescents				
Amin et al. (2008)(23)	Eating food away from home >3 times/week was associated with overweight/obesity (OR 1.76; 95% CI 1.28-2.42) compared with eating away from home ≤3 times/week.	Age, maternal education, maternal occupational status, family size, taking breakfast at home, residence.	Y	+
Ayala et al. (2008)(26)	Eating at restaurants ≥1 times/week was associated with overweight/obesity in children (p≤0.05) compared with lower frequency of eating at restaurants. Eating at relatives, neighbors or friends homes ≥1 times/week was associated with overweight in children (p≤0.05) compared with lower frequency of eating at those places.	Income.	Y (for eating in restaurants) Y(for eating at any place away from home)	+
Elfhag et al. (2010)(60)	Overweight boys had lower level of external eating than normal weight boys (p<0.01). No significant association between overweight and external eating was observed in girls (p>0.05).	Age, parental education.	Sex interaction	+
Kosti et al. (2007)(98)	Eating away from home ≥2 times/week was not associated with overweight/obesity in boys (p=0.28) and in girls (p=0.79) compared with eating away from home <2 times/week.	Crude analysis.	N	0
Li et al. (2010)(101)	Eating breakfast away from home was not associated with overweight/obesity (OR 1.2; 95% CI 0.6-2.4) compared with not eating breakfast away from home.	Age, sex, residence, household wealth index, parental BMI.	N	+
Nicklas et al. (2004)(122)	Eating meals away from home was not associated with overweight status (OR 1.04; 95% CI 0.94-1.14) compared with not consuming meals away from home.	Sex, ethnicity, total energy intake, study year.	N	++
Snacking: Longitudinal studies in children and/or adolescents				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Novaes et al. (2008)(126)	Frequent snacking in commercial establishments was associated with obesity (OR 4.66; 95% CI 1.26-20.38) compared with not frequent snacking in those places.	Crude analysis.	Y	0
Eating away-from-home: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Ayala et al. (2008)(26)	Eating at restaurants ≥1 times/week was associated with overweight/obesity in parents (97.7% mothers) (p≤0.05) compared with lower frequency of eating at restaurants. Eating at relatives, neighbors or friends homes ≥1 times/week was not associated with overweight in parents (p>0.05) compared with lower frequency of eating at those places.	Income	Y (for eating in restaurants) N (for eating at any place away from home)	+
Berg et al. (2008)(31)	Eating away from home was not found to be associated with obesity (OR 0.88; 95% CI 0.70-1.10).	Age, sex, education, physical activity, smoking, employment status.	N	++

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Eating away-from-home: Cross-sectional studies in adults (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Bezerra et al. (2009)(38)	Eating away from home ≥1 time/week was associated with overweight in men (OR 1.12; 95% CI 1.02-1.24) and with lower frequency of overweight in women (OR 0.88; 95% CI 0.80-0.97) compared with not eating away from home. Eating away from home ≥1 time/week was associated with obesity in men (OR 1.23; 95% CI 1.05-1.43) but not in women (OR 0.94; 95% CI 0.82-1.07) compared with not eating away from home.	Age, income	Sex interaction	+
Binkley et al. (2000)(41)	The percentage of total food eaten at restaurants was associated with overweight in men (p<0.05) but not in women (p>0.05). A greater percentage of total food eaten at restaurants was associated with a higher body weight in men (0.89 kg; 95% CI 0.10, 1.68 kg) but not in women (0.17 kg; 95% CI -0.79, 1.13 kg).	Crude analysis	Sex interaction	0
Casey et al. (2008)(47)	Often eating away from home was associated with obesity (OR 1.46; 95% CI 1.02-2.09) compared with not often eating away from home.	Age, sex, education, intervention status (walking promotion).	Y	+
Elfhag et al. (2010)(60)	External eating was not associated with overweight in men and in women (p>0.05).	Age, education.	N	+
Ma et al. (2003)(104)	<u>Eating breakfast</u> away from home more frequently (last quartile) was associated with obesity (OR 2.21; 95% CI 1.14-4.69) compared with eating breakfast away from home less frequently (first quartile). <u>Eating lunch</u> (OR 0.70; 95% CI 0.36-1.37) or <u>eating dinner</u> (OR 1.89, 95% CI 0.93-3.83) away from home more frequently (last quartile) were not associated with obesity compared with eating lunch or dinner away from home less frequently (first quartile).	Age, sex, education, total physical activity, total energy intake.	Y (for eating breakfast away from home)	+++
Mahmood et al. (2010)(108)	Eating lunch away from home was associated with obesity (OR 7.11; 95% CI 2.28-22.09) compared with eating lunch at home.	Age, marital status.	Y	+
Marin-Guerrero et al. (2008)(109)	Eating away from home was not associated with obesity (p>0.05). Specifically, eating breakfast (in men OR 1.12, 95% CI 0.99-1.28; in women OR 1.07, 95% CI 0.86-1.36), <u>lunch</u> (in men OR 1.03, 95% CI 0.92-1.15; in women OR 1.03, 95% CI 0.84-1.26) or <u>dinner</u> (in men OR 1.14, 95% CI 0.95-1.37; in women OR 1.03, 95% CI 0.84-1.26) away from home were not associated with obesity compared with having those meals at home.	Age, educational level, physical activity, smoking, alcohol consumption, health status, size of town of residence, marital status.	N	++
Veugelers et al. (2005)(165)	Buying <u>lunch</u> at school was associated with overweight (OR 1.39; 95% CI 1.16-1.67) compared with bringing lunch from home.	Parental education, participation in physical activities, frequency of physical education classes in school, lunch and family supper.	Y	+++

Eating away-from-home: Longitudinal studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Bes-Rastrollo et al. (2010a)(36)	Eating away from home ≥2times/week was associated with weight gain (+129 g/year, 95% CI +62, +97 g/year; p<0.001), with gaining ≥2 kg (OR 1.36; 95 % CI 1.13-1.63), and with risk of incident overweight/obesity (HR 1.33; 95% CI 1.13-1.57) compared with never eating or up to 3 times/month away from home. Eating away from home 1 time/week was not associated with weight gain (+15 g/year, 95% CI -55, +86 g/year), with gaining ≥2 kg (OR 1.12; 95 % CI 0.92-1.37), but it was associated with risk of incident overweight/obesity (HR 1.22; 95% CI 1.02-1.45) compared with never eating or up to 3 times/month away from home.	Age, sex, years of education, leisure-time physical activity, baseline smoking, smoking during follow-up, fiber intake, alcohol intake, total energy intake, snacking, following any special diet, baseline BMI.	Y	+++
Duffey et al. (2007)(58)	Increased away from home consumption (restaurant food) was not associated with BMI change after 3 years of follow up (β -0.01; 95% CI -0.21, 0.19).	Age, sex, race, education, physical activity, income, energy intake, study center, family structure, fast food, restaurant intake, smoking.	N	+++

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S7. Association between fast food consumption and excess weight, by study design and population.

Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Fast food consumption: Cross-sectional studies in children and/or adolescents				
Bin Zaal et al. (2009)(40)	Eating fast food ≥4 times/week was associated with lower frequency of obesity in girls (OR 0.5; 95% CI 0.3-0.8) but not in boys (OR 1.1; 95% CI 0.7-1.7) compared with eating fast food 1-3 times/week.	Crude analysis.	Sex interaction	0
Duncan et al. (2008)(59)	Frequency of fast food intake (1-2, 3-4 or ≥5 servings/week) was not associated with overfat status (OR 1.35, 95% CI 0.83-2.21; OR 0.67, 95% CI 0.22-2.07; OR 2.38; 95% CI 0.48-11.8, respectively) compared with no consumption.	Age, sex, ethnicity, socioeconomic status, physical activity, active transport, sports participations, lunch bought at school, breakfast, fast food, sugary drink, weekday sleep, weekend sleep.	N	+++
French et al. (2001)(70)	Frequency of fast food restaurant use food was not associated with overweight in boys and in girls (p>0.05). Eating restaurant fast food ≥3 times/week was associated with lower BMI in boys (22.4 kg/m^2) compared with eating at fast food never (23.5 kg/m^2) or 1-2 times/week (23.2 kg/m^2) (p<0.05). Eating fast food was not associated with BMI in girls (p>0.05).	Race, socioeconomic status, grade, school.	N	+
Li et al. (2010)(101)	Local energy-dense fast food (mutton and beef soup) consumption was not associated with overweight/obesity in boys (OR 1.2; 95% CI 0.7-1.8) but it was associated with overweight/obesity in girls (OR 1.7; 95% CI 1.04-2.9).	Age, sex, residence, household wealth, parental BMI.	Y	+
McDonald et al. (2009)(113)	Eating fast food (hamburger or hotdog) ≥1 time/week was associated with overweight/obesity (PR 1.93; 95% CI 1.03-3.62) compared with lower frequency.	Age, sex, socioeconomic status, total energy intake, maternal BMI, number of household assets.	Y	+
Pirincci et al. (2010)(135)	Eating fast food ≥2 times/week was associated with overweight and obesity (OR 1.46; 95% CI 1.21-1.77) compared with eating fast food <2 times/week.	Crude analysis.	Y	0
Sanigorski et al. (2007)(139)	Eating fast food >1 time/week did not show an association with overweight/obesity (OR 1.1; 95% CI 0.8-1.4) compared with eating fast foods ≤1 time/week.	Age, sex, socioeconomic index for areas.	N	+
Shan et al. (2010)(142)	Eating Western fast food 1-2 times/week was not associated with overweight (OR 0.80; 95% CI 0.60-1.06) and obesity (OR 1.33; 95% CI 0.95-1.86) compared with eating fast foods <1 time/week. Eating Western fast food ≥3 times/week was not associated with overweight (OR 1.02; 95% CI 0.80-1.29) but it was associated with obesity (OR 1.50; 1.12-2.02) compared with eating fast food <1 time/week.	Age, sex, Tanner stage, urban/rural residence.	Y (for obesity)	+
Vagstrand et al. (2007)(161)	Fast food intake was not correlated with percentage of body fat in boys and in girls (Spearman's correlation coefficient= -0.08 and 0.02, respectively) (p>0.05).	Crude analysis.	N	0
Veugelers et al. (2005)(165)	Eating at fast food restaurant ≥3 times/week was not associated with overweight (OR 0.86; 95% CI 0.57-1.12) compared with eating fast food <1 time/week.	Crude analysis.	N	0

Fast food consumption: Longitudinal studies in children and/or adolescents				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Niemeier et al. (2006)(123)	Eating at fast foods at baseline was associated with BMI *Z* score after 5 years of follow up (β 0.02, p<0.05) compared with not eating at fast foods.	Age, sex, race/ethnicity, parental education, physical activity, BMI *Z* score at baseline, maternal obesity, month of interview, sedentary behavior, change in sedentary behavior over the follow up.	Y	++
Taveras et al. (2005)(151)	Intake of fried food away from home (as a proxy of fast food) at baseline was cross-sectionally associated with BMI (trend p=0.002). Increasing fried food intake away from home from <1 time/week to 4-7 times/week was associated with increased BMI over 1 year of follow up (β 0.21; 95% CI 0.03, 0.39) compared with maintaining fried food frequency at <1 time/week over the follow-up.	Age, sex, race/ethnicity, physical activity and inactivity, baseline and follow-up menstrual status (girls), Tanner stage, baseline height, annual change in height, previous BMI *Z* score.	Y	++

Fast food consumption: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Bezerra et al (2009)(38)	Eating fast foods away from home ≥1 time/week was associated with overweight in men (OR 1.20; 95% CI 1.01-1.42) and with lower frequency of overweight in women (OR 0.79; 95% CI 0.64-0.97) compared with not eating fast foods away from home. Eating fast foods away from home ≥1 time/week was not associated with obesity in men (OR 1.20; 95% CI 0.93-1.56) and in women (OR 0.94; 95% CI 0.71-1.25) compared with not eating fast foods away from home.	Age, income.	Sex interaction (for overweight). N (for obesity)	+
Binkley et al. (2000)(41)	The percentage of total food eaten at fast food restaurants was associated with overweight in men (p<0.01) and in women (p<0.05). The greater percentage of total food eaten at fast food restaurants was associated with a higher body weight in men (0.82 kg; 95% CI 0.13, 1.49 kg) and in women (0.95 kg; 95% CI 0.12, 1.79 kg).	Crude analysis.	Y	0
Boo et al. (2010)(43)	Fast food consumption and the median number of times of fast food consumption/week were not associated with overweight or obesity (p=0.7, p=0.4, respectively).	Crude analysis.	N	0
Bowman et al. (2004)(45)	Eating fast food was associated with overweight both for only one of the two survey days (OR 1.27; CI 95% 1.13-1.42) and for eating fast food both survey days (OR 1.31; 95% CI 1.1-1.57) compared with not eating fast food.	Age, sex, race/ethnicity, household annual income, geographic region, urbanization.	Y	+
Casey et al. (2008)(47)	Often eating at fast foods was associated with obesity (OR 1.38; 95% CI 1.04-1.84) compared with not often eating at fast foods.	Age, sex, education, intervention status (walking promotion).	Y	+
Frank et al. (2009)(67)	Fast food intake was not associated with BMI in white men (p>0.05) but it was associated with higher BMI in white women (p=0.001). Fast food intake was not associated with BMI in black women and men (p>0.05).	Age, education, income, number in household, number of vehicles in household, number of children in household, employment, walkability of home, shopped at grocery store.	Sex interaction among whites	+

Fast food consumption: Cross-sectional studies in adults (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Jeffery et al. (2006)(88)	Eating at fast food restaurants ≥1 times/week was associated with higher BMI (β 0.301, p=0.02) compared with not eating at fast food.	Age, sex, education.	Y	+
Schroder et al. (2007)(140)	Fast food intake (g/day) was associated with BMI (β 1.76; 95% CI 0.22, 3.29). Eating fast food ≥1 time/week was slightly associated with 'the risk of obesity' (p=0.057).	Age, sex, educational status, leisure-time physical activity, smoking, alcohol consumption, energy intake from non-fast food sources.	Y	+++
Fast food consumption: Longitudinal studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Bes-Rastrollo et al. (2006)(35)	Those in the highest quintile of fast food consumption showed an increases risk (OR 1.2; 95% CI 1.0-1.4) of any weight gain compared with those in the lowest quintile.	Age, sex, leisure-time physical activity, total energy intake from non-fast-food sources, fiber intake, alcohol intake, smoking status, snacking, television watching, baseline weight, gaining ≥3 kg in the past 5 years.	Y	+++
Bes-Rastrollo et al. (2010b)(37)	Those in the highest tercile of fast food intake did not show a statistically significant increase in the risk (OR 1.31; 95% CI 0.83-2.07) of substantial weight gain (≥3 kg/year) or in the risk (OR 1.11; 95% CI 0.80-1.55) of becoming obese compared with those in the lowest tercile.	Age, sex, physical activity, television viewing, sitting time, total energy intake, baseline BMI, usual snacking, sugar sweetened beverages, fiber intake, alcohol intake, smoking.	N	+++
Duffey et al. (2007)(58)	Fast food intake at restaurants at baseline was associated with an increase in BMI (0.16 ±0.05 kg/m^2) after 3 years of follow up. Increased fast food intake at restaurants during follow up was associated (β 0.20; 95% CI 0.01, 0.39) with a prospective increase in BMI over the follow up period.	Age, sex, race, education, physical activity, income, caloric intake, study center, family structure, fast food, restaurant intake, smoking.	Y	+++
French et al. (2000)(69)	An increase of one fast food meal per week (at restaurant) was associated with a weight gain of 0.72 kg (standard error=0.20 kg) over 3 years (p=0.01).	Age, ethnicity, income, marital status, baseline body weight, frequency of fast food restaurant use at baseline, treatment group (receiving periodic invitation to take part in eating and exercise programs).	Y	+
Jeffery et al. (1998)(87)	Frequency of fast food consumption (times/week) was not associated with BMI in men (β -0.10; 95% CI -0.43, 0.23) but it was associated with BMI in high-income women (β 0.39; 95% CI 0.15, 0.64) and low-income women (β 0.85; 95% CI 0.43, 1.27). Frequency of fast food consumption (times/week) was not associated with 1-year BMI change in men (β -0.23; 95% CI -0.56, 0.11), in high-income women (β 0.02; 95% CI -0.05, 0.09) and in low-income women (β -0.06; 95% CI -0.20, 0.08).	Age, education, physical activity, total calories, percentage of fat, smoking, baseline BMI, BMI change only.	Sex interaction for BMI N (for BMI change)	+++

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Fast food consumption: <u>Longitudinal</u> studies in <u>adults</u> (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Pereira et al. (2005)(132)	The baseline frequency of eating at fast foods was associated with change in body weight in white people (β 1.56, p=0.0064) and in black people (β 2.22, p=0.0014). Eating at fast foods >2 times/week both at baseline and at the end of follow-up was associated with a 4.5 kg weight gain (p=0.0054) compared with eating fast food <1 time/week in both periods. Changes in the frequency of eating at fast foods over 15 years of follow-up was associated with changes in bodyweight in white (β 1.84, p<0.0001) but not in black people (β 0.74, p=0.1053).	Age, sex, education, physical activity, total energy intake, study centre, baseline bodyweight and height, cigarette smoking, alcohol intake, television viewing, intake of satured fatty acids, unsatured fatty acids, trans-fatty acids, fiber, daily serving fruits, non-starchy vegetables, wholegrains, refined grains, soft drinks, meat, dairy, fish.	Y	+++

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S8. Association between consumption of takeaway food and excess weight, by study design and population.

Takeaway food consumption: Longitudinal study in children and/or adolescents				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Thompson et al. (2004)(153)	The frequency of eating quick-service food at baseline was positively associated with change in BMI z-score (F=6.49, P<0.01) over time. No association was found for food purchased in other establishments (restaurants, coffee shops)	Baseline BMI *Z* score.	Y	+
Takeaway food consumption: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
McCrory et al. (1999)(112)	The higher frequency/month of eating takeaway foods (from restaurants) was associated with increased body fatness (p=0.005).	Age, sex, educational level, smoking, alcohol intake.	Y	+
Simmons et al. (2005)(145)	Takeaway food consumption ≥1 time/month was not associated with obesity defined by both BMI (OR 0.85; 95% CI 0.63-1.13) and waist circumference (OR 1.08; 95% CI 0.83-1.41) compared with not consuming takeaway food.	Age, sex, exercise at least 150 min/week, use full-fat milk, drinking ≥1 unit alcohol/day, town of residence, television watching, use of low-fat spread, consumption of vegetables, consumption of fruit, current daily smoker, cut fat off the meat, cut skin off the chicken.	N	+++
Smith et al. (2009)(146)	Takeaway food consumption ≥2 times/week was not associated with overweight in men (PR 0.98; 95% CI 0.88-1.09) but it was associated with overweight in women (PR 1.22; 95% CI 1.03-1.45) compared with takeaway food consumption <2 times/week. Takeaway food consumption ≥2 times/week was not associated with obesity in men (PR 1.21; 95% CI 0.90-1.63) and in women (PR 1.29; 95% CI 0.93-1.80) compared with takeaway food consumption <2 times/week. Takeaway food consumption ≥2 times/week was associated with abdominal obesity in men (PR 1.31; 95% CI 1.07-1.61) and in women (PR 1.25; 95% CI 1.04-1.50) compared with takeaway food consumption <2 times/week.	Age, leisure time physical activity, television viewing, employment status	N (for general obesity) Y (for abdominal obesity)	++

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S9. Association between portion size and excess weight, by study design and population.

Study	Results	Adjusted variables	Conclusion*	Adjustment**
Portion size: Cross-sectional studies in children and/or adolescents				
Colapinto et al. (2007)(50)	Eating larger portion sizes of french fries (OR 0.99; 95% CI 0.87-1.13), meats (OR 1.01; 95% CI 0.87-1.18), vegetables (OR 1.11; 95% CI 0.99-1.24) and potato chips (OR 0.97; 95% CI 0.83-1.12) were not associated with overweight.	Sex, parent education, parent income, residency, family supper, supper in front of television, eating at fast food restaurant, parent eating habit.	N	+
Huang et al. (2004)(84)	Meal portion size (g) was associated with BMI percentile in boys aged 3 to 5 years (β 0.024, p=0.01) but not in boys of other age, and in girls (p>0.05). Snack portion size (g) was associated with BMI percentile in boys aged 6 to 11 years (β 0.029, p=0.01) but not in boys of other age, and in girls (p>0.05).	Ethnicity, percentage above poverty, urbanicity, geographic region, daily television viewing.	Y (for boys aged 3-5 y) Y (for boys aged 6-11 y)	++ ++
Lioret et al. (2009)(103)	Larger portion sizes of biscuits (p for trend=0.0392) and sweetened pastries (p for trend=0.0027) were associated with overweight in children aged 3-6 years. Larger portion sizes of liquid dairy products were associated with lower frequency of overweight in children aged 7-11 years (p for trend=0.0006). No associations was found between overweight and portion size for the following items: sweet or savory snacks, croissant-like pastries, fast foods, breakfast cereals, solid dairy products, solid fruits and vegetables, starchy foods, meat, ham, meat products, poultry and game, fish, eggs, cheese, mixed dishes, fat spreads, liquid dairy products, juices and soups, carbonated sweetened beverages, non-carbonated soft drinks.	Age, sex. Results for sweetened pastries and liquid dairy products were also adjusted for leisure time physical activity, sedentary behavior, and dietary energy density.	N (in most cases)	+++ (for observed associations)
McConahy et al. (2002)(111)	Higher average portion sizes were associated with higher percentiles of body weight (p<0.05).	Crude analysis.	Y	0
Mercille et al. (2010)(114)	Mean portion size (g) of fast food intake was not associated with BMI (p=0.08).	Crude analysis.	N	0
Sun et al. (2009)(149)	Eating very large volumes (OR 15.7; 95% CI 6.93-35.83), large volumes (OR 9.54; 95% CI 4.50-20.23) and normal volumes of food (OR 2.65; 95% CI 1.26-5.57) were associated with overweight in boys compared with eating a small volume of food. Eating very large volumes (OR 4.26; 95% CI 1.63-11.13), large volumes (OR 5.47; 95% CI 3.01-9.94) and normal volumes of food (OR 2.70; 95% CI 1.55-4.70) were associated with overweight in girls compared with eating a small volume of food.	Age, paternal overweight, maternal overweight, breakfast eating frequency, nighttime snacking, eating speed, eating volume, physical activity, television watching time, video game playing time, sleep duration	Y	++
Portion size: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment****
Berg et al. (2008)(31)	Eating larger portion sizes of main meals was associated with obesity (OR 1.13; 95% CI 1.05-1.21).	Age, sex, education, physical activity, smoking, employment status.	Y	++
Kent et al. (2010)(94)	Eating larger breakfast portion sizes was associated with lower BMI in men (p<0.05) but not in women (p>0.05).	Age, education, marital status.	Y (lower BMI with larger sizes in men)	+
Liebman et al. (2003)(102)	Eating more often supersized portions was not associated with overweight (β 0.08, p=0.20) but it was with obesity (β 0.19, p=0.0035) compared with eating supersized portion less often.	Crude analysis.	Y	0

Portion size: Cross-sectional studies in adults (continued)				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment****
Wansink et al. (2008)(169)	Eating in a large plate was associated with higher BMI (OR 1.16; 95% CI 1.04-1.30).	Age, sex.	Y	+

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

Table S10. Association between eating until full and excess weight, by study design and population.

Eating until full: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Maruyama et al. (2008)(110)	Eating until full was associated with overweight in men (OR 2.00, 95% CI 1.53-2.62) and in women (OR 1.92; 95% CI 1.53-2.40) compared with not eating until full.	Age, regular physical activity, occupation, smoking, total energy intake, total dietary fiber intake, alcohol intake, survey area.	Y	+++
Nishitani et al. (2009)(124)	Eating until full was associated with obesity (OR 1.58; 95% IC 1.31-1.91) compared with not eating until full.	Age.	Y	+
Eating until full: Longitudinal studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Toyoshima et al. (2009)(159)	Eating until satiety was associated with higher BMI compared with eating moderately at baseline both in the low-stress stratum (22.92 and 21.83 kg/m^2, respectively) and in the high-stress stratum (23.17 and 21.78 kg/m^2, respectively) (crude analysis). Eating until satiety was associated with higher BMI change over 5 years of follow-up in the high-stress stratum (p=0.002) but not in the low-stress stratum (p=0.80) compared with eating moderately (p for interaction between mental stress and satiation eating=0.03).	Age, exercise, energy intake at the end of follow up, BMI at baseline, drinking, smoking habits.	Y (in those with high stress)	+

CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

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Table S11. Association between eating quickly and excess weight and metabolic syndrome, by study design and population.

Study	Results	Adjusted variables	Conclusion*	Adjustment score**
Eating quickly: Cross-sectional study in children and/or adolescents				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Sun et al. (2009)(149)	Eating very fast (OR 4.16; 95% CI 2.22-7.82), fast (OR 3.33; 95% CI 1.94-5.72) and in a normal speed (OR 2.32; 95% CI 1.36-3.95) were associated with overweight in boys compared with eating in a slow speed. Eating very fast (OR 2.92; 95% CI 1.23-6.91), fast (OR 2.55; 95% CI 1.65-3.96) and in a normal speed (OR 1.69; 95% CI 1.15-2.47) were associated with overweight in girls compared with eating in a slow speed.	Age, paternal overweight, maternal overweight, breakfast eating frequency, nighttime snacking, eating speed, eating volume, physical activity, television watching time, video game playing time, sleep duration.	Y	++
Eating quickly: Longitudinal studies in children and/or adolescents				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Barkeling et al. (1992)(28)	The obese children ate faster (42±14 g/minute) than normal weight children (33±14 g/minute) (p<0.05).	Crude analysis.	Y	0
He et al. (2000)(78)	Eating quickly (high eating speed) was associated with obesity in children aged 0.1-2.9 years (OR 3.50; 95% CI 1.90-6.44) and in children aged 3-6.9 years (OR 8.58; 95% CI 6.06-12.14) compared with lower eating speed.	Crude analysis.	Y	0
Laessle et al. (2001)(99)	The overweight children ate significantly faster than normal weight children only when the mother was present in the laboratory (p<0.05).	Age, sex.	Interaction by presence of mother	+
Eating quickly: Cross-sectional studies in adults				
Study	**Results**	**Adjusted variables**	**Conclusion***	**Adjustment score****
Maruyama et al. (2008)(110)	Eating quickly (eating fast and very fast) was associated with overweight in men (OR 1.84; 95% CI 1.42-2.38) and in women (OR 2.09; 95% CI 1.69-2.59) compared with not eating quickly.	Age, regular physical activity, occupation, smoking, total energy intake, total dietary fiber intake, alcohol intake, survey area.	Y	+++
Nishitani et al. (2009)(124)	Eating quickly was associated with obesity (OR 1.50; 95% CI 1.25-1.79) compared with not eating quickly.	Age.	Y	+
Otsuka et al. (2006)(129)	Eating quickly (very fast) was associated with BMI in men (β 1.47; 95% CI 1.20, 1.75) and in women (β 1.34; 95% CI 0.74, 1.94) compared with eating with a medium rate.	Age, physical activity, smoking status, alcohol drinking habit.	Y	++
Shin et al. (2009)(143)	Eating quickly (fast meal speed) was associated with the metabolic syndrome (OR 2.23; 95% CI 1.60-3.12) compared with slow meal speed.	Age, physical activity, smoking, family history of type 2 diabetes.	Y	++

β: beta coefficient; CI confidence interval; HR: hazard ratio; OR: odds ratio. *Conclusions for the associations considered in this review: Y (yes, association observed), N (no association), I (inconsistent results in the same study). **Classification for adjusted variables: (0) crude analysis; (+) adjusted for age, sex and a socioeconomic indicator; (++) adjusted as + and additionally for physical activity/sedentariness and smoking; (+++) adjusted as ++ and additionally for energy intake or eating behaviors.

List of articles excluded according to specific criteria.

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Study with overlapping data: 1 article excluded

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***Overlapping data with the following article (included in the review):**

Utter J, Scragg R, Mhurchu CN, Schaaf D. At-home breakfast consumption among New Zealand children: associations with body mass index and related nutrition behaviors. J Am Diet Assoc 2007;107(4):570-6

12.2 Material suplementario Artículo 3 “Food sources of sodium, saturated fat and added sugar in the Spanish hypertensive and diabetic population” (This document is available as Supplemental Material for inclusion as online documentation).

Supplementary table 1. Top five food sources of sodium in the Spanish population free of diagnosed hypertension or diagnosed diabetes, by sex and age.

	Sex				**Age,** *years*					
	Men		**Women**		**18-44**		**45-64**		**≥ 65**	
	Rank	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**
Population free of diagnosed hypertension, ***N=9,471***										
Bread	1	32.7	1	34.0	1	32.0	1	35.2	1	35.9
Raw-cured sausages	2	16.5	2	12.1	2	14.5	2	15.3	2	13.3
Cooked sausages	3	6.6	3	6.5	3	7.3	3	5.7	4	4.7
Cured cheese	4	3.8	5	3.5	5	3.6	5	4.0	-	-
Soups	5	3.8	4	4.2	4	3.4	4	4.1	3	5.8
Olives	-	-	-	-	-	-	-	-	5	4.2
Population free of diagnosed diabetes, ***N=11,159***										
Bread	1	33.0	1	34.4	1	32.0	1	35.1	1	36.3
Raw-cured sausages	2	16.7	2	12.0	2	14.5	2	15.7	2	12.8
Cooked sausages	3	6.3	3	6.3	3	7.3	3	5.5	4	6.0
Soups	4	3.9	4	4.4	4	3.6	4	4.1	3	4.4
Cured cheese	5	3.8	5	3.5	5	3.4	5	3.9	5	4.1

Supplementary table 2. Top five food sources of saturated fat in the Spanish population free of diagnosed hypertension or diabetes, by sex and age.

	Sex				**Age,** *years*					
	Men		**Women**		**18-44**		**45-64**		**≥ 65**	
	Rank	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**
Population free of diagnosed hypertension, *N=9,471*										
Cured cheese	1	12.0	2	11.4	2	10.4	1	13.8	1	14.6
Baked goods, pastries and cookies	2	11.7	1	11.7	1	12.2	2	11.2	2	10.3
Red meat	3	11.0	3	9.5	3	10.4	3	10.3	3	10.0
Raw-cured sausages	4	9.4	4	6.3	4	8.0	4	8.5	4	6.9
Whole milk and milkshake	5	6.4	-	-	-	-	5	4.8	5	4.8
Fats	-	-	5	6.1	5	6.1	-	-	-	-
Population free of diagnosed diabetes, *N=11,159*										
Cured cheese	1	12.2	1	13.8	2	12.1	1	13.5	1	14.7
Baked goods, pastries and cookies	2	11.6	2	11.2	1	10.5	2	11.3	2	10.4
Red meat	3	10.9	3	10.3	3	10.4	3	10.2	3	9.8
Raw-cured sausages	4	9.4	4	8.5	4	8.0	4	8.7	4	6.6
Whole milk and milkshake	5	5.9	5	4.8	-	-	5	4.6	5	4.6
Fats	-	-	-	-	5	6.0	-	-	-	-

Supplementary table 3. Top five food sources of added sugar in the Spanish population free of diagnosed hypertension or diabetes, by sex and age.

	Sex				**Age**, *years*					
	Men		**Women**		**18-44**		**45-64**		**≥ 65**	
	Rank	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**
Population free of diagnosed hypertension, *N=9,471*										
Sugar, honey and syrups	1	24.3	1	24.3	1	20.9	1	33.2	1	29.5
Soft drinks	2	18.7	2	14.2	2	20.2	4	9.4	-	-
Baked goods, pastries and cookies	3	11.3	4	11.1	4	10.3	2	12.9	2	14.0
Chocolate	4	10.9	3	13.3	3	12.7	3	11.0	5	9.0
Whole yogurt and fermented milk	5	9.3	5	9.1	5	9.4	5	8.0	3	10.4
Jam and Jelly	-	-	-	-	-	-	-	-	4	10.4
Population free of diagnosed diabetes, *N=11,159*										
Sugar, honey and syrups	1	24.9	1	24.6	1	21.0	1	32.2	1	29.8
Soft drinks	2	17.5	2	13.6	2	20.0	4	9.5	-	-
Baked goods, pastries and cookies	3	11.6	4	11.4	4	10.4	2	12.7	2	14.8
Chocolate	4	11.1	3	13.2	3	12.7	3	11.8	5	9.3
Whole yogurt and fermented milk	5	9.3	5	9.0	5	9.5	5	8.0	4	9.6
Jam and Jelly	-	-	-	-	-	-	-	-	3	10.1